MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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London, S.W.1 2 Caxton St., Westminster

Published by The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on the seventh of each month.

This Month's Cover: Rotary can filling machine designed by Horix Manufacturing Co. Accelerated pitch on infeed screw positions each can accurately for pickup by starwheel feeding the filler. A corresponding starwheel on the discharge side places the cans in position on a conveyor. Laminated plastics infeed and discharge rails protect lithographed cans.

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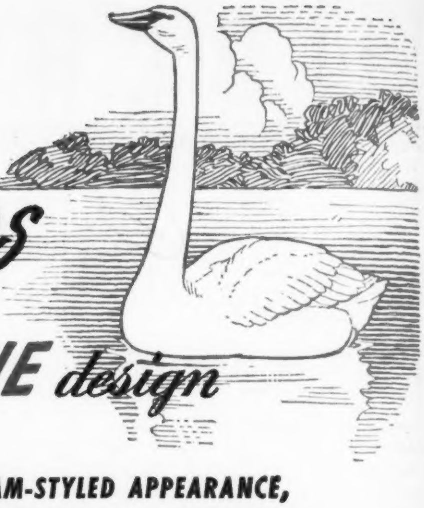
September, 1948 — Vol. 20, No. 9

Quiet running Smoothly floating—

RESILIENT MOUNTED MOTORS



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Itemized Index

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Topics

CONTINUOUS PRODUCTION of carbon and alloy steels from the liquid phase to semi-finished shape in one simple operation has become a practical reality through a joint development of the Republic Steel Corp. and The Babcock & Wilcox Tube Co. Obviating equipment for ingots, soaking pits and the blooming mill, the method cools the steel quickly, producing a fine grain rather than columnar crystal structure.

RAMIE, one of the world's oldest vegetable fibers is now being used as packing for reciprocating pumps. It is recommended for use on cold water and brine pumps because of its high tensile strength and ability to absorb and retain lubricants, minimize abrasion and prolong wear.

STORAGE BATTERY failures resulting from not maintaining proper water level in the cells are reduced by the use of transparent vent caps. These "thirst quenchers", developed by B. F. Goodrich Co., are so designed that the words "add water" become visible whenever the water level gets low.

SILICONE PAINT for automobiles and domestic equipment will give life-time finish that will retain its original color and gloss indefinitely. Tests on the paint, still in the development stage at General Electric, show that the silicone product is resistant to severe weather conditions, chemicals and heat.

BRONZE COATING of steel gears by a casting process developed in Germany gives greater strength and longer life to the gears than could be obtained from solid cast gears, especially where shock is encountered.

TITANIUM METAL offers promising possibilities for applications in aircraft structures and engines where increasing quantities of special steels are being used. Possessing a unique combination of strength, light weight and corrosion resistance, it is equivalent to stainless steel in many respects but its weight is about 40 per cent less. To develop alloying potentialities and methods of fabricating, Remington Arms Co. Inc. is distributing samples of unalloyed metal for field evaluation as an engineering material.

EQUIPMENT for economically converting sunlight to electricity is among the needed items in the latest list of technical problems affecting national defense released by the National Inventors Council. The council hopes that inventors will submit solutions or suggest approaches which may lead to solutions.

CHROMIUM PLATING to precision tolerance of 0.00002-inch on the balls and races of antifriction bearings has been developed by Cro-Plate Co., Hartford, Conn. To retain lubricants, the plating is electrolytically etched with a fine screen.

ELECTRIC HEATERS for refrigerators, made of electrically conductive rubber by U. S. Rubber Co., prevents "sweating" or condensing of moisture on the cabinet exterior. The heater strip is placed between the freezing compartment and the regular cold chamber, keeping the dividing member free of moisture without materially affecting the temperature of the refrigerator.

DEFICIT of approximately 500,000 tons per year in domestic copper production confronts American industry, according to C. Donald Dallas, chairman of the board, Revere Copper and Brass Inc. Because subsidizing production in marginal mines would probably yield no more than 10 per cent of the deficit and accumulating virgin stocks from abroad would take years, Mr. Dallas suggests the accumulation of brass scrap. This mixture of copper and zinc could be stored in billet form as a reserve for emergency.

MACHINE DESIGN

Appearance Starts With Color!

By Howard Ketcham
Color and Design Engineer
Howard Ketcham, Inc.
New York 17

A MANUFACTURER of private airplanes styled his aircraft all white—"as clean as a milk-wagon". Seen against the proper, dark background on the ground, it appeared larger than its actual size. But something was lacking; the colorless plane lacked personality and distinction. Aloft, its white exterior blended with the clouds and the craft quickly became invisible in flight.

New styling, in highly visible red and yellow was established, with "speed lines" to give an effect of motion even while standing. The little craft looked impressive on the ground or in the air. The manufacturer's sales force could easily prove that the plane would not remain unnoticed long in the event of forced landing in rural districts; nor did it lack attention at sales hangars.

Some color combinations just can't help calling for attention. To prove this, look down from atop a big-city skyscraper and notice how the taxicabs dominate the city's street traffic. (Then go downstairs and try to get a cab in a hurry, to see how scarce they really are!)

Today, in home and office, in store and factory, the general public is more conscious of color than ever before. A survey of housewives in Greensboro, North Carolina, revealed that three out of five women under 35 years of age had some training in color—in home economics courses or in art studies. We have found in other studies of consumer color preferences just how much more fully the correct use of color is appreciated today than in the past. Thus, shrewd manufacturers, planning ahead against the time when

products will require more effective selling, can tap a rich market opened to them by the power of color appeal.

A broad segment of American industry has come to recognize the importance of color in producing consumer goods that sell. When colorful plastic fountain pens were introduced by a one-time jeweler named Schaeffer in 1924, the industry's sales shot up 50 per cent, and soon only one out of ten fountain pens were color-styled in familiar blacks and reds. Substitution of aluminum paint for black on bedsprings boosted one manufacturer's sales by 25 per cent.

Selling power of color may be used in three ways in machine design: (1) To attract attention before sale, using high-visibility colors in arresting combinations; (2) to improve functioning by sharply defining the different operating parts; and (3) to fit the color and lighting background against which the machine will be seen in use.

For the first two uses, sharp contrasts are particularly apt. Various tests have been devised to show the combinations with greatest contrast. For example, to determine the color most sharply defined against the sky, balloons of many colors were flown aloft. The yellow remained in sight longest. Thus it is that a certain yellow is the standard color for most school buses. It stands out most strongly against the horizon on country roads, and also offers high visibility against rural foliage.

The six combinations of colors which provide the sharpest contrast when used together, as shown by tests of legibility, are:

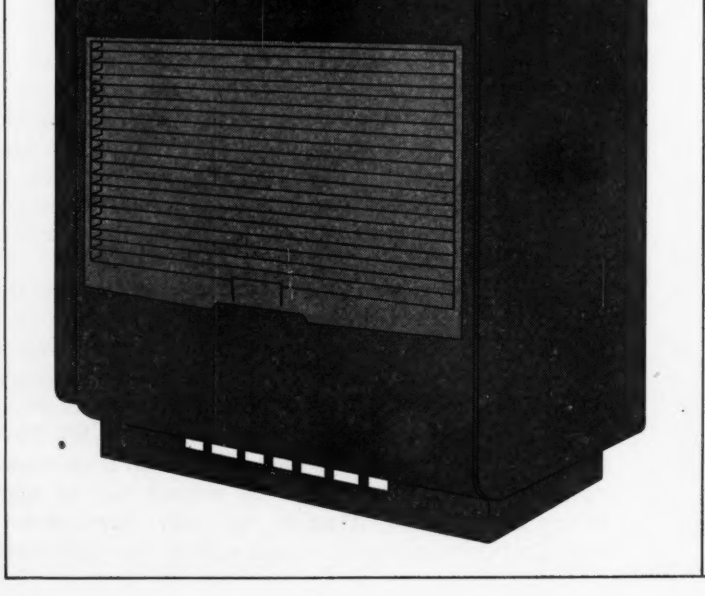
Black on yellow	Blue on white
Green on white	White on blue
Red on white	Black on white

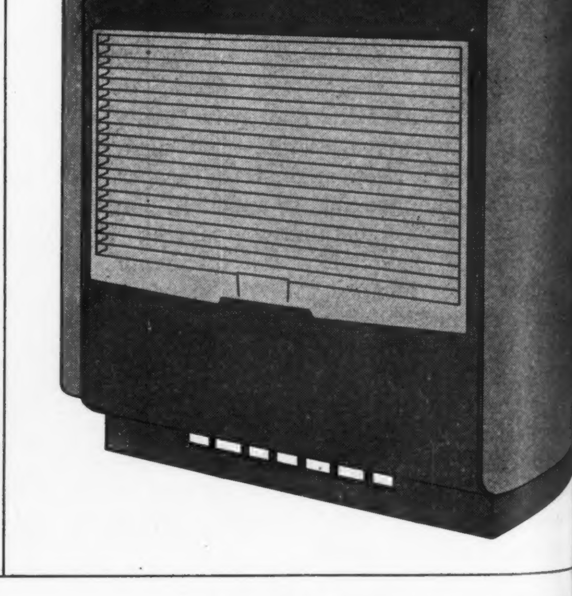
Other combinations which provide sharp contrast are yellow on black, white on red, white on green, and white on black.

Of course, these combinations are not all appropriate for machinery nor for office equipment or consumer goods, for that matter. White is seldom suited to plant machinery, because of the glare caused by its high reflectivity and because it soils too readily. (White has been used in machinery profitably as a color for machinery levers in a textile mill; because it showed soilage, it impressed machine operators with the need to keep their hands clean, and reduced the spoilage of textile fabrics due to stains.)

Speeding of the tempo of office routine in recent years has been accompanied by progressive development in office colors and lighting. Walls in cool gray-greens and cheery buffs provide an atmosphere that is bright and clean. Lighting is color-corrected, with blue-green fluorescent fixtures combined with the reddish-yellow incandescents and with the newer reddish-toned fluorescent lamps. But in the development of designs for office equipment there has been a lag in the application of color, partly because strong demand has made production speed more essential than consumer appeal. Since 90 per cent of persons over 45 suffer from visual defects, according to the Better Vision Institute, an improvement in conditions of seeing will pay dividends in the production record of office staffs.

Below—Three sketches show alternative treatments for a space heater, with function and size of room determining the most desirable. Wall, flooring and furnishings colors are other factors in the selection. Sketch at left shows a solid-color treatment for all areas with the exception of the grille trim in contrasting chrome or light color; this treatment is less conspicuous in a small room than the other sketches. Middle sketch shows dark areas on front and base, with lighter colors on sides and grille in light color or chrome. Sketch at right with light-colored front and base, dark sides, and chrome grille, shares with the middle sketch an effect of greater interest. However, the lighter colors make the last sketch appear larger, convey the impression that the customer is getting more heater



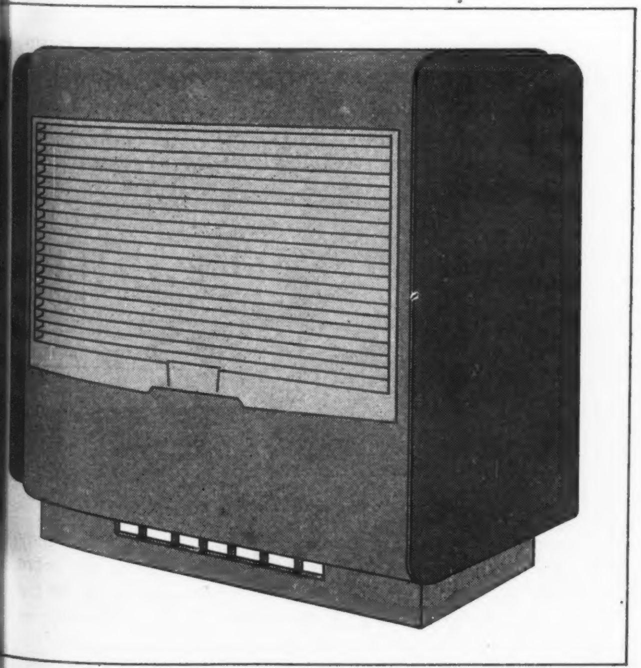


Styling of office machines has progressed no further, for the most part, than the use of crackled or crystalline finishes, which do not readily show scratches. But this finish does attract dust, and it is so commonly used that it provides no individual appeal for the product. ("Me, too!" is hardly a powerful selling point in product styling!)

Recent reports that peak demand for office space has passed presage an end to the sellers' market in office equipment. New appeals will be needed to attract the potential buyer. Manufacturers have recognized the appeal of color in designing portables. L. C. Smith, for example, offered eleven colors before the war, with as many as thirty "college-color" specials. It may yet be found that color applications which improve working conditions and increase secretarial output can also do a selling job for the office-machine manufacturer, by developing a replacement market.

For example, it would be helpful to large organizations, in which office machines are borrowed back and forth between departments, to have equipment with the body housing in different colors; a color-code would indicate where a borrowed machine belonged. How much time-saving would accrue if everyone could tell at a glance that the tabulator Research had borrowed should be returned to Purchases—which has all equipment in turquoise—and not to Accounting, whose office machines are beige!

The colors suited for an office typewriter are not the same as those which appeal to the college student, housewife, or others who buy portables for home use. Colors for the office are designed both to minimize glare and to reflect light efficiently. Stimulation of the office machine operator is achieved by introducing such energizing colors as creams, yellows, tans, yellow-greens and golden-browns. And while the portable owner may appreciate keys with maximum contrast colors, the professional typist using the "touch" system would be indifferent to such use of color.



With 23 years' service to such companies as Pan American World Airways, Du Pont, and General Electric, Color and Design Engineer Howard Ketcham speaks authoritatively on the inter-relationship of color, form and lighting. During the post-war period he has styled interiors for new aircraft for Pan American; designed trucks, pumps, tank cars and stations for Cities Service Oil Company; and styled the coaches and diesel locomotives for Jersey Central Lines. He has served as chairman of the Color Survey Committee of the National Paint, Varnish and Lacquer Association, and as a member of the Color Co-ordination Committee of the National Retail Dry Goods Association.

Elimination of soporific colors has proceeded progressively in office styling. Filing cabinets and desks formerly were finished in olive-drab green or mahogany browns; today, metallic gray is the sales leader. Even livelier colors may be developed for such equipment, to enliven the emotional tone and to stimulate greater activity. Such restyling will require care, however, in order to prevent overstimulation.

It should be borne in mind that color exerts decided influences upon thoughts and impulses, varying in some degree with the individual. Emotional responses trace back as far as the history of mankind, when the red of fire signified heat, the yellow of the sun at dawning meant life, etc. Other responses to color are governed by associations in the individual's past experience. The "psychological primaries" of color, embodying emotional response, are shown in TABLE I. Selection of newer colors for office equipment and for the background areas will depend upon correct adaptation of these psychological primaries.

Correct color treatment for office machinery will involve styling to blend harmoniously with the average work-area background, i.e., the desk, walls, etc. As brighter color treatment is introduced into office furnishings, new color solutions will evolve in the styling of the equipment.

Such an effect has been achieved, for example, in the beige adding machine marketed for some years by L. C. Smith. Introduced originally for cashier accounting, the color has been particularly popular in beauty parlors, drug stores, groceries, and other places where it was desired to avoid the finger-marking common on glossy black surfaces of office machines.

Most tabulating machine manufacturers have em-

ployed two colors on different columns of keys; improving the accuracy of operations thereby. Formerly, sharply contrasting colors were employed, but today some manufacturers use two shades of the same color to avoid excessive distraction to the eye. It would be interesting to determine from actual operating tests how far it is efficient to carry color differentiation among the columns of keys; while a different color for each column might cause confusion, various combinations of three or four colors might speed operation of the machine.

Influences of Surface Texture

Introduction of textural effects through modern finishes on office equipment can have even greater impact than new colors used in familiar treatments. We have observed the trend toward mirror-like surfaces, in such varied applications as plastic seat-arms for railroad coaches, glass-fronted stores, Koroseal fabrics, and the application of Du Pont's reflectant Metalli-chrome in automobile body finishes. This lacquer finish has pigment particles so small that the film is transparent to a great depth, creating an attractive luster. Light rays penetrate into the film before reflecting back to the eye, and the incorporation into the finish of fine aluminum flakes adds to the effect. The finish offers possibilities for many other consumer items.

Other finishes which enliven surface interests include the spattered type, which creates a glossy two-color effect; the hammered-finish types simulate the mottled texture of hammered metals; and Rigid-Tex, the rigidized metals rolled in any of a number of textured patterns and finished in a variety of colors. Rigid-Tex, which conceals finger-marks through its pattern designs, is particularly well adapted to dictating machines, which are subject to much handling. It is available in blue, neutral, gray, dusty rose, beige, green, chartreuse, turquoise and golden yellow; colors well suited to office use.

No color styling program is complete if the same thought and care devoted to the product itself is not also given to color treatments for the trademark, display, packaging, company vehicles and letterhead. An integrated program which adapts colors and design styling to all of these features builds prestige and valuable consumer recognition.

Effective results are obtained when consideration of these factors commences at the stage of initial development of design styling. At this point, planning is still fluid and all factors may be weighed. Color styling, and the selection of finishes, cannot be imposed with maximum effect after the design lines have been established, for color is the governing factor in form.

Design exerts no influence over color; however, correct color can improve the appearance of form. If the human eye saw all objects in the same color and the same texture, there would be no question of design. We recognize the shapes of objects through different colors and textures in adjoining areas. Without this faculty of vision, everything would appear in a flat, continuous plane.

For this reason, design starts with color. An indication of the recognition given by manufacturing executives to the color problem is seen in the report that company presidents would share in the final choice of colors in three out of four companies planning colors changes.

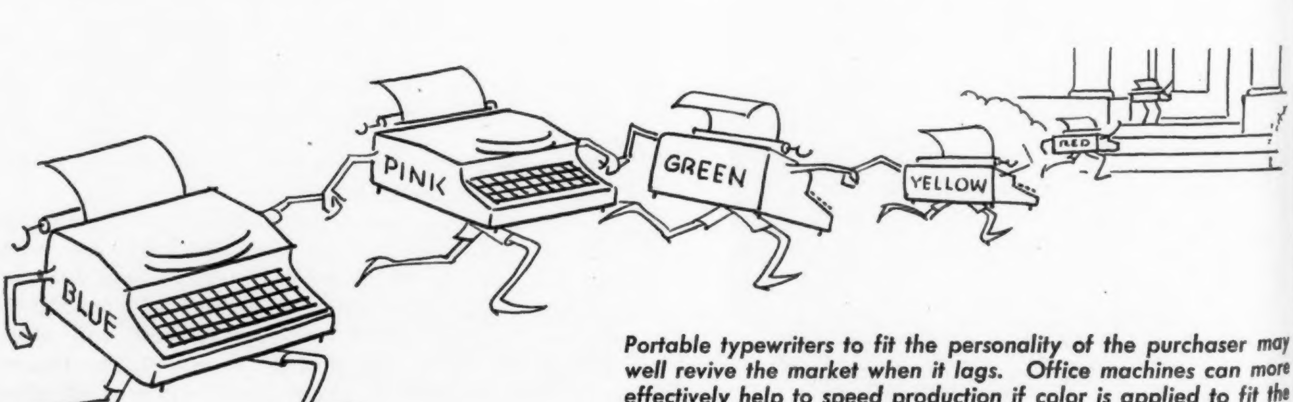
Yet in the average manufacturing concern there is no provision for color design based on the specific requirements of the product's market. Staff organizations are established for performance design, production, sales and other important features of moving the product to its greatest potential market. But the basic factor in appearance-appeal is most often superimposed after the basic concepts of styling have become set.

In establishing colors for machines, a variety of considerations must be established as a starting step:

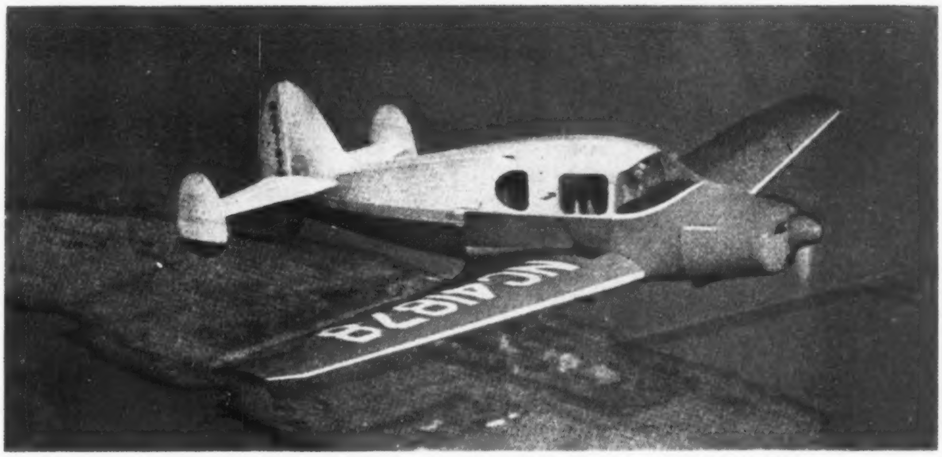
1. Personality of the user
2. Conditions of use
3. Lighting conditions in operation
4. Durability and maintenance

Some colors are masculine, some feminine, in their appeal. Office machines to be used by a woman will lend spirit to the typist or bookkeeper if finished in colors that appeal to her taste. It is no accident that motorcycles, operated almost exclusively by men, are seldom seen in the delicate colors which automobile manufacturers sometimes offer to appeal to the women in the family.

Some machines require colors which are governed by their location. An electric clock for an executive's



Portable typewriters to fit the personality of the purchaser may well revive the market when it lags. Office machines can more effectively help to speed production if color is applied to fit the office background colors, to suit the taste of the operator, or to indicate the department to which a machine is assigned



Post-war Bellanca Cruisair in cream and red, offers high visibility, both on the ground and aloft. Colors are applied to make the plane appear larger, more personalized, and to add to the impression of speed

office would require a different color treatment than a bedroom or kitchen clock. Air conditioning fixtures, now offered in a drab color treatment designed for office use, will never become really popular with housewives until they blend harmoniously with home furnishings colors.

The light under which a machine is seen is a fundamental consideration in planning its colors. Office machines, viewed at close range under artificial illuminants, require a grayed color to prevent glare; road machinery, operated in strong daylight against an outdoor background, require high-visibility colors that do not pale against the bright outdoor setting. The Willys-Overland Company, for example, maintains a vivid red in its color line for jeeps and trucks, to meet the needs of sportsmen and rural operators, while introducing softer colors more suited to city browns and grays.

Machines subject to hard usage and soilage require the low-value (darker) colors which reveal less dirt and scuffmarks. A vacuum cleaner which is bumped against furniture and subject to dirt will serve best in dark browns and grays, and with easily cleaned gloss surfaces such as those offered by some plastics. The walls of a railroad coach under the windows are apt to feel the imprint of a passenger's foot as much as six times an hour, we found by actual count. A textured metal surface, with dull-finish color applied, offered the best chance for railroad operating personnel to keep appearance neat.

Color as an Aid in Dentistry

One type of machine whose color styling combines all the considerations mentioned is the dentist's office equipment. Of America's 78,000 dentists, the average practitioner buys equipment twice during a lifetime, spending $5,000 to set himself up after graduating from dental school. Typically, a dentist with 15 years' experience and growth in practice opens a new office which lasts for the remainder of his career. Most dentists are not business men enough to appreciate the importance of presentation as a vital part in practical success. But many are willing to learn, as a small-city Minnesota dentist learned when his wife proved that proper color treatment in the office relieved the uneasiness of many timorous patients. With more-relaxed patients he was able to complete treatments with saving in time, and thus to serve a larger clientele.

For the most part, dental equipment is offered in cream or tan today, with a selection of mahogamy also in cabinets. Many dental equipment supply houses offer suggestions as to the furnishing and layout of the office. But much may be done to add a touch of color, to instill the proper mood. Within the limitations imposed by the need for colors which also bear the connotation of sanitary cleanliness, and which reflect sufficient light while eliminating some of the glare now caused by the proximity of dental-office illuminants, dental equipment may be finished in colors which harmonize with those of office and reception room, to ease the tension of the average patient.

TABLE I

Psychological Primaries of Color

Color	Psychological Significance
Red—Orange	Heat; warmth; stimulation; activity
Yellow—Yellow-green	Freshness; dryness; crispness, relaxation
Green—Blue	Coldness; passivity
Violet	Humidity; limpness; dullness

Color	Emotional Effects
Red	Stimulating or cheering to the melancholy or lazy; upsetting to the nervous or overactive
Blue	Soothing to the nervous; depressing to the morose
Yellow	In certain hues, the sensation of glory, cheerfulness, wealth; in other variations, cowardice, cheapness, sickness
Green	Cooling, not productive of extreme reactions
Brown	Depressing if used alone; best combined with orange, yellow, gold
Purple	Associated with heroism and magnificence, or with passion, suffering and mystery

Again, the accompanying table of color psychology may be applied to determine appropriate colors. It must be remembered that the meaning of color is changed by some of the most minute changes in the color. For example, a pure purple-red half-way on the scale between light and dark has an exhilarating mood, but with elimination of the red cast conveys a mournful effect.

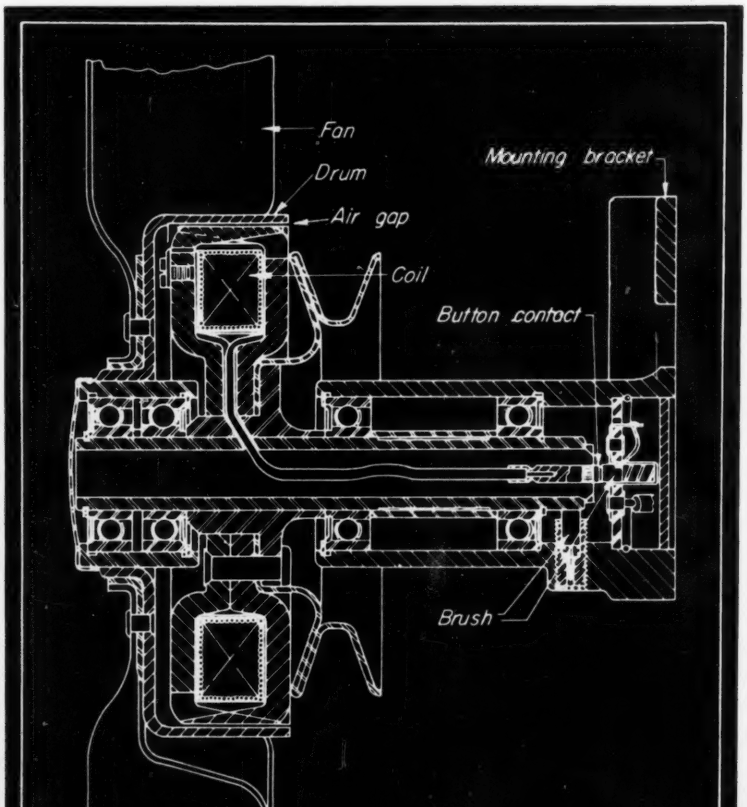
The manufacturer who senses the importance of design and color, and who knows how to select and

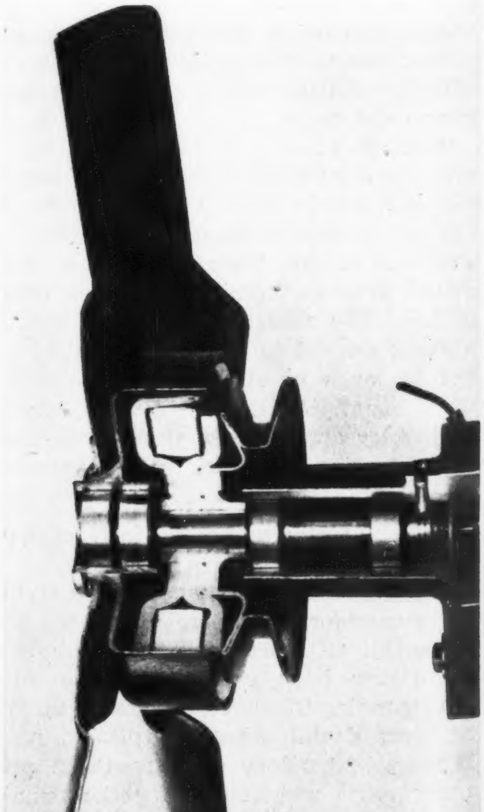
(*Concluded on Page* 188)

Scanning THE FIELD for Ideas

Eddy-current clutch, below, designed for driving the engine fan of Ford cars assures better engine operation and savings in fuel up to 10 per cent. Controlled by a thermostat in the coolant system, the fan provides no cooling until the engine comes up to proper operating temperature. During normal driving conditions the fan is idle as much as 80 per cent of the time, relieving the engine of the fan load which may be as much as 6½ hp at high speeds. By using a clutch with proper electrical characteristics and a smaller driving pulley than employed on a direct-driven fan, the unit provides additional cooling capacity at low engine speeds where it is most frequently needed.

This clutch, known as the Dynamatic Drive, is built by the Eaton Manufacturing Co. and operates on the well-known electromagnetic principle used on larger industrial and marine drives. Shown in cross section, below, it consists of a drum and rotor assembly mounted on a common shaft. The

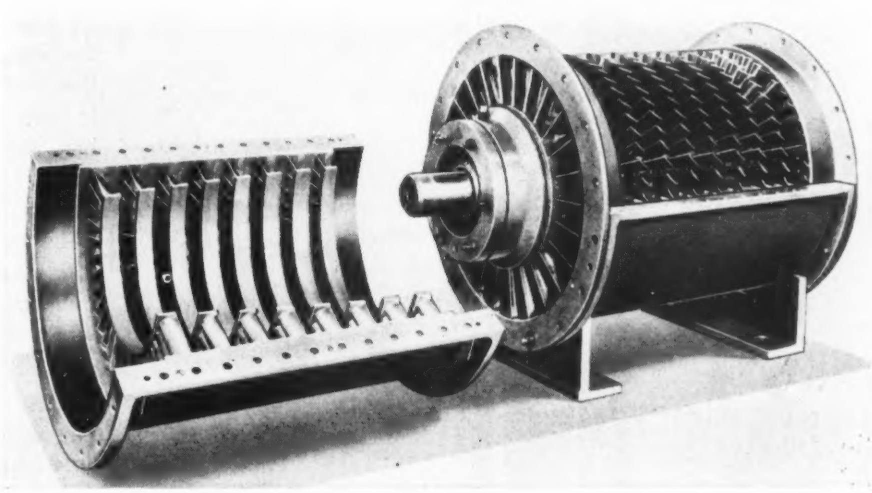




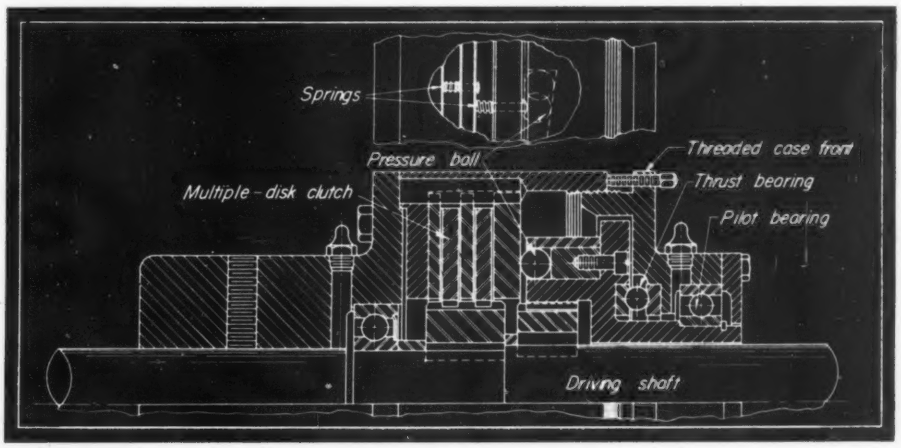
drum is affixed to the fan and the rotor to the fan-belt pulley. With the pulley connected to the engine, the fan is driven only at speeds corresponding to the amount of current flowing through the coil of the clutch rotor.

Electrical circuit is from the battery through the carbon-pile thermostat to the clutch coil and back to the battery. The rotary connection from the thermostat to the coil is shown in the cross-sectional view. The incoming lead is connected to a spring-loaded brush bearing on a button contact. One end of the coil is connected, through a hole in the clutch shaft, to the button and the other is grounded through another brush on the shaft side to the engine block.

Current to actuate the clutch is negligible, seldom reaching 1 amp. Engagement of the clutch, responding to the thermostat, is controlled by a small bellows-actuated carbon-pile rheostat having a range from 18 to 0.4-ohm resistance. Operating between engine temperatures of 150 to 170 F, the thermostat element increasingly applies pressure to the carbon pile to reduce its resistance. Well adapted to applications requiring a high degree of slip to very little slip, this clutch transmits high torque without wear or overheating.



Axial-flow compressor, right, delivers 18,000 cubic feet per minute at 25-lb gage pressure yet has a diameter of only 17 inches. Each rotor blade rotates in the incoming air stream and deflects air passing across its surface through a small angle. This deflection requires a small amount of work resulting in a reaction against the blade and a compression of the air. Blades are shortened in length from leading edge to trailing edge in proportion to the compression. Each blade is shaped and twisted so that its cross section varies throughout its length in accordance with requirements of an air velocity vector analysis which will produce working sections having high ratios of the forces normal to the blade chords and the forces in the direction of the chords. Each stage, consisting of a row of stationary and rotating blades, is capable of increasing the pressure by 20 per cent. Practical number of stages in this type of compressor designed by Fredric Flader Inc. is limited by the temperature rise of the air and the size of the smallest blades. Pressure ratios of 7 to 1 are considered the practical limit, resulting in a discharge pressure of approximately 100 psi. Compression efficiencies of 88 per cent are considered attainable in commercial practice. Efficiencies approaching adiabatic have been achieved in tests.



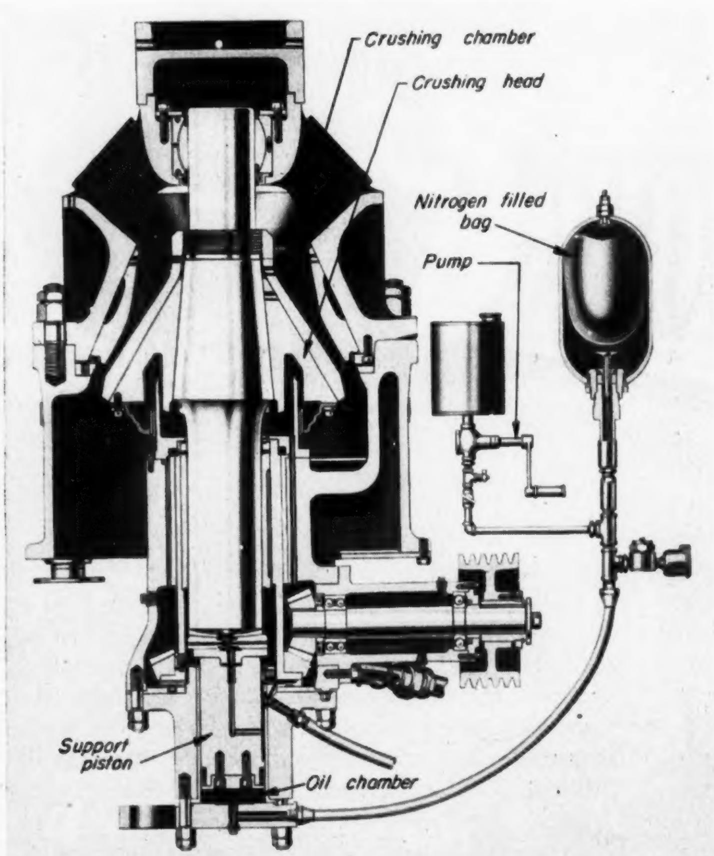
Overrunning clutch, right, is designed by the Kinney Manufacturing Co. to obviate transmitting all of the driving power through balls, rollers or other forms of wedge parts used between driving and driven members. The clutch employs a multidisk mechanism with spline-driven drive plates, working pressure being applied by cam-actuated balls when the driving

shaft rotates the clutch mechanism.

Instead of carrying full power through the engaging means, causing deformation and flats which require excessive drag to disengage, the pressure balls transmit only working pressure. This is a comparatively small part of the clutch capacity. Remainder of the capacity is transmitted to the drive plates through the driving spline. The time required for building up this working pressure has the advantage of gradual pickup or engagement.

The case front bearing acts as a pilot bearing in the overrunning position, supporting the front of the clutch mechanism. These parts are designed as a unit and the clutch adjustment is obtained simply by turning the threaded case. Springs between the drive plates provide free-running space between the plates and exert a light pressure on the pressure balls in the overrunning position. When the driving element applies a load to the clutch, the balls all start up the cam incline from the same position and the pressure load is distributed evenly between them.

To provide no-drag disengagement, the resultant pressure from the balls and cams is transferred to a thrust bearing. At the moment of disengagement the pressure balls and thrust balls are retained in races which turn in opposite directions, thus requiring a minimum of drag.



Automatic reset for the Allis-Chalmers crusher, cutaway view shown above, is a simple positive device for returning the head to position after it has retracted to pass an unbreakable object. Utilizing a steel cylinder surrounding a bag containing nitrogen at high pressure, the system automatically relieves the crusher head setting when the pressure in the system increases to the point where it exceeds the pressure in the bag, opening the valve at the bottom of the cylinder. Hydraulic oil then flows into the cylinder, compressing the gas in the bag. As the oil flows into the cylinder, the crushing head lowers enough to permit the unbreakable material to be discharged.

When the material has passed, the pressure on the head no longer exceeds the original pressure in the bag. The oil is then forced back into the hydraulic system and the crusher head is reset to its original position. After the oil has returned, a valve in the bottom of the cylinder closes as the bag comes in contact with it. To change product size or to compensate for wear, a pump is used to change the amount of oil in the hydraulic system. Increasing the amount of oil raises the head, while decreasing the amount lowers it.

Swiveling wheels, Swiveling wheels, below, on the Goodyear DC-3 add safety and utility for cross-wind landings of the plane. These wheels have their castering mechanism built within the hub. The plane is the first twin-engine model to be approved with castered landing gear.

TWELVE YEARS To Discover the Obvious!

Steps in the evolution of a variable speed transmission

By L. A. Graham
Graham Transmissions Inc.
Milwaukee

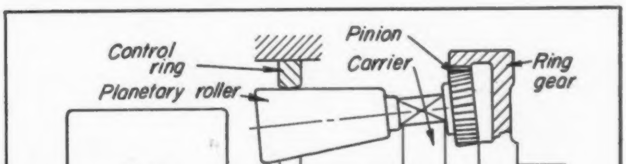
THIS article takes the reader behind the scenes and tells of the successive steps in reaching the solution to what would appear to be a relatively simple problem in machine design. As so often happens the answer, when finally arrived at after a series of five detours covering a period of twelve years, proved to be the simplest, most direct, most economical and—it must be admitted—the most obvious.

The problem concerned a single element in the design of a variable speed transmission using metallic rolling traction, *Fig.* 1. It was to find the best way to mount the tapered planetary rollers in their carrier so that they would contact the encircling ring and build up the tractional force required. To understand what was wanted, the operation of this transmission, as more fully described in the author's article, "Planetary Transmissions", MACHINE DESIGN, Nov., 1946, will be reviewed briefly.

This drive is the counterpart of the familiar compound differential planetary geared transmission, known to millions of early motorists in the Model T Ford, except that tapered rollers on inclined axes contacting an encircling traction ring replace the three sets of planetary pinions and contacting gears used in the Ford. It will be remembered that by selectively engaging the clutch or wrapping a brake band around drums fastened to two of the contacting gear sets, the Ford was put into high, low or reverse. In the Graham transmission, instead of three speeds an infinite number is had by moving the stationary contact ring axially along the outside of the planetary rollers (whose outer edge is parallel to the central axis, since the taper of the rollers equals their inclination) to engage an infinite number of different diameters of the rollers and so give all speeds from top to zero and reverse.

Calculation of the output speed in the Graham is similar to that in the Ford. At the small end of each of the planet rollers there is fastened a planet pinion which meshes with a mating ring gear keyed to the output shaft. The linear speed of this ring gear is the difference between the constant linear speed of the motor at the pitch line of the gearing minus the linear speed about its own axis of the planet pinion, which is made to rotate in the opposite direction from the motor by the friction or reaction of the tapered roller against the ring. As the con-

Fig. 1—Diagram showing the essential elements of variable speed transmission using metallic rolling traction



trol ring is moved to the small end of the roller, the roller with its pinion turns faster in the ratio of the relative diameters of roller and ring bore until the speed of the pinion about its own axis equals its speed about the central axis, at which point the output speed becomes zero. Beyond this point, the output shaft reverses.

The problem is to so mount the rollers in their carrier or spider, *Fig.* 1, as to secure the traction needed to give the roller its planetary rotation. Incidentally, since this rotation is produced against the resistance at the teeth of the ring gear, arising from the external applied load, the numerical value of tangential tractional force required at each roller contact must equal the gear tooth pressure times the pitch radius of the planet pinion, divided by the radius of the roller at its contact point with the control ring. This reaction force, which again may be likened to the reaction between rail and driving wheel necessary to push a locomotive ahead against the drawbar pull and other resistances, is derived from the radial force between roller and ring, times the available coefficient of friction or traction. Since the transmission runs in oil, this coefficient is very much less than in a locomotive or automobile that uses dry traction, so that the radial force between roller and ring must be correspondingly greater. This radial force is had by pushing the roller against the ring by the centrifugal force due to its rotation, or by a spring, or by a torque-actuated cam or other device, or by a combination of these loading means. The roller must be so mounted in the carrier as to permit the development of such force, and herein—as already stated—lies the subject of this article.

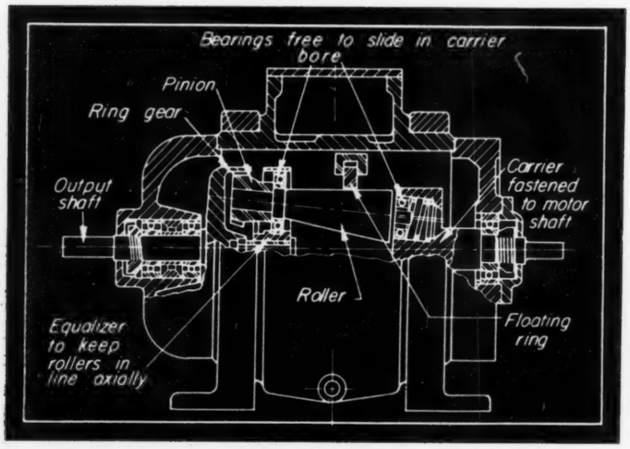


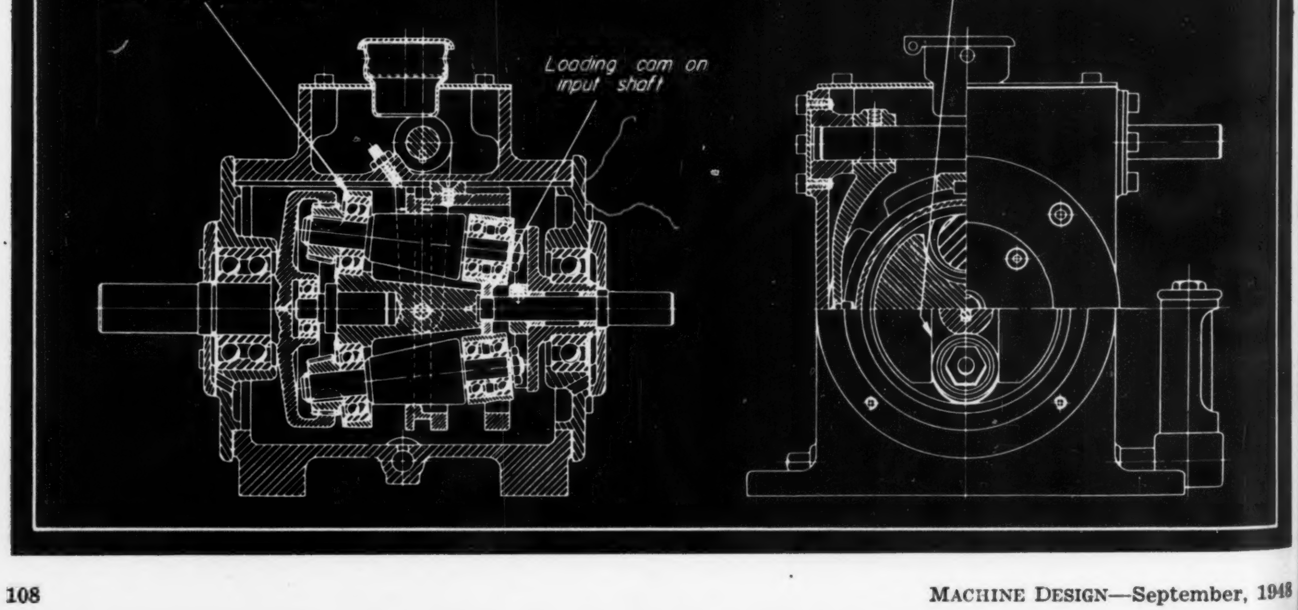
Fig. 2—Above—First design had bearings which were free to move outward in inclined bores in the carrier under the influence of centrifugal force and a spring

Fig. 3—Below—Second design employed torque-responsive loading applied through a cam on the input shaft

First Design: *Fig.* 2 shows the original mounting employed for this purpose (the drawing is reproduced from *Kent's Handbook,* 11th edition, 1936). Each of the three planetary rollers has a bearing at each end, loosely fitted in inclined bores in the carrier. When the spider rotates at motor speed, the centrifugal force acting on each roller urges the roller outward along its inclined axis.

Since the bearings of the roller are free to move up in the carrier bores, they will do so until the rollers contact the floating ring. Assuming that the centrifugal force is then completely absorbed by an equal and opposite force of contact at the ring, these two forces comprise a couple which may obviously be balanced in theory by a corresponding couple developed by the two bearing reactions, each of which then equals numerically the amount of the couple divided by the bearing span.

Unfortunately, the pitfall in this assumption is that conceivably one bearing could be omitted, in which case the centrifugal force (plus spring pressure back of the roller where used) could be fully sustained by the other bearing and the ring, in which event the bearing reaction, when the ring was adja-



cent to it, might be as much as eight times as great as if both bearings were operative. In other words, the bearing reactions were inherently indeterminate in this design and in practice the bearings proved inadequate since each should have been large enough (if space permitted) to carry the full load, in which case, of course, one of them might as well have been left out.

SECOND DESIGN: This was, in effect, done in the second design, *Fig.* 3, as far as supporting the centrifugal force was concerned. The bearing at the larger end of the roller was now carried in a slide in the carrier which evidently provided no outward reaction, the slide merely serving to locate the roller tangentially. This tangential location was necessary since a single fixed spherical bearing was substituted in this design for the two outwardly sliding bearings, the roller now being free to swing radially, on the bearing center as a pivot, into contact with the ring.

An incidental advantage of this mounting was that each roller moved independently of the others and the ring, instead of floating, could be given a minimum sliding clearance in the housing; whereas in the previous design, in addition to the floating ring, an equalizing device was necessary to keep the rollers in step axially as they moved up into the ring bore.

This second design also introduced a new method of loading the rollers to augment and largely replace the centrifugal force. It was considered an advantage to have the loading force increase with increase in load so as (1) to relieve the contact pressure when the external load was light, and (2) to prevent slippage when the load became heavy.

Although this idea of "torque-responsive" loading is attractive in theory there turned out to be two good reasons against its use in the Graham. First, in the Graham a complete slip at the roller contact is impossible even in the case of a complete stall of the driven shaft because the roller will continue to roll within the ring, even though the output shaft is held against rotation. Thus, torque responsive loading is not necessary in the Graham to prevent destructive slippage as with other devices, and actually the Graham serves in many applications as a form of load limiting clutch to safeguard the driven machine and transmission against dangerous momentary overloads which are inevitable in certain types of equipment such as conveyors. But the second and more important reason for the abandonment of torque loading is that in case of a jam at low speeds, where the motor protective devices do not function, the forces in the transmission itself may then reach destructive values and thus do as much harm as the very slippage which this type of loading aims to avoid.

THIRD DESIGN: Accordingly, in the third design,

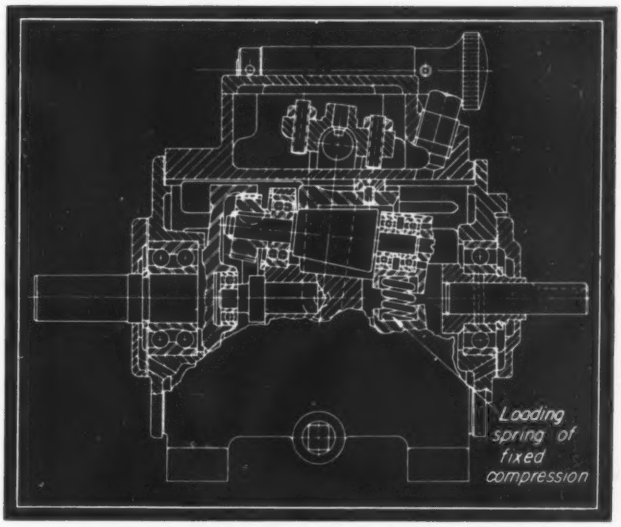
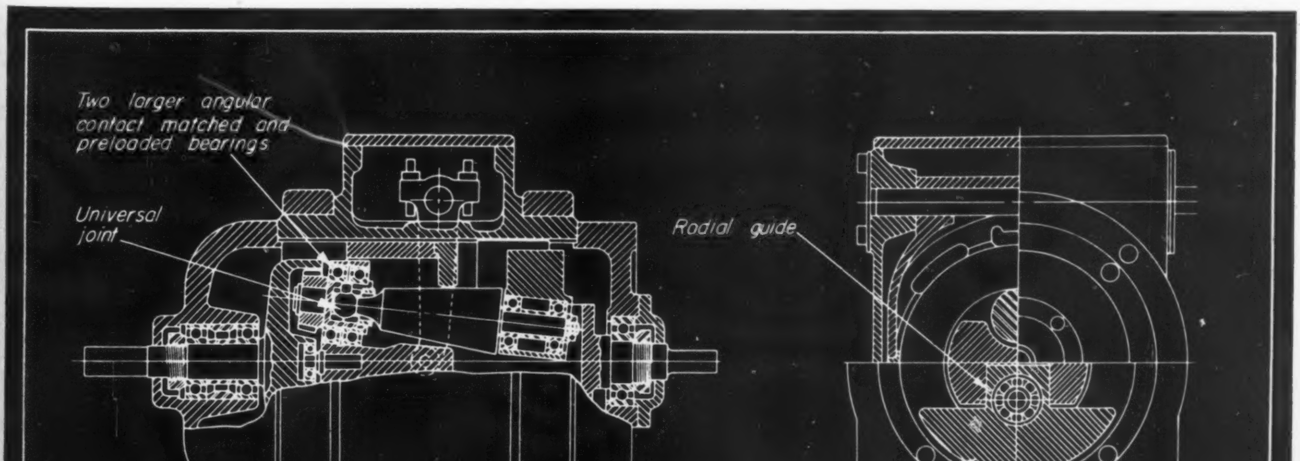


Fig. 4—Above—Third design had fixed instead of torque responsive loading, by spring plus centrifugal force

Fig. 5—Below—Fourth design had special universal joint at small end of roller instead of spherical bearing. Auxiliary weight provided additional centrifugal force



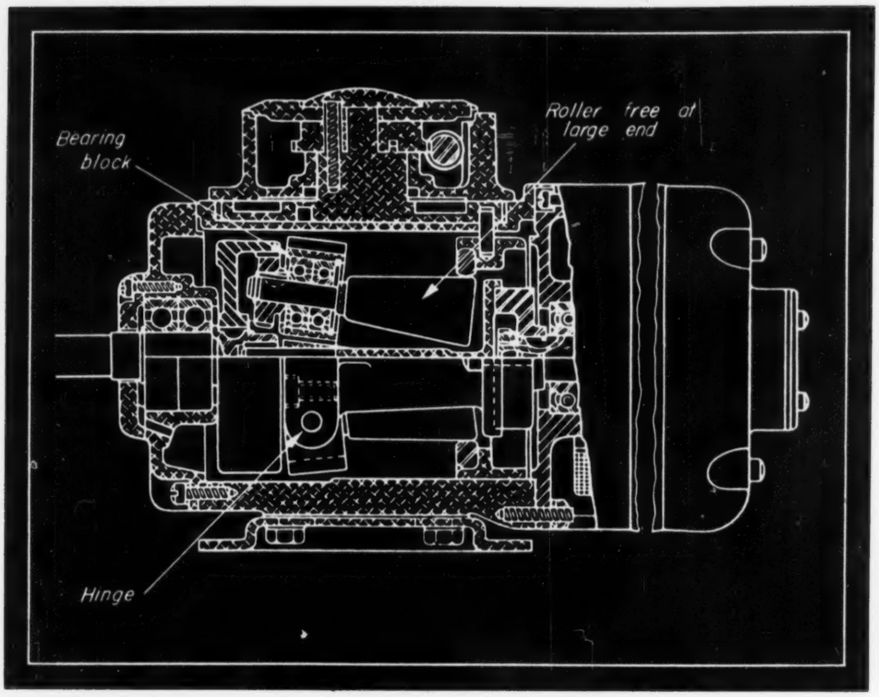


Fig. 6—Left—In fifth design rollers were free at their large end and carried in hinge-mounted double ball bearings at small end

Fig. 7—Below—Roller and carrier assembly for fifth design, showing hinge mounting to permit rollers to move out into contact with the ring

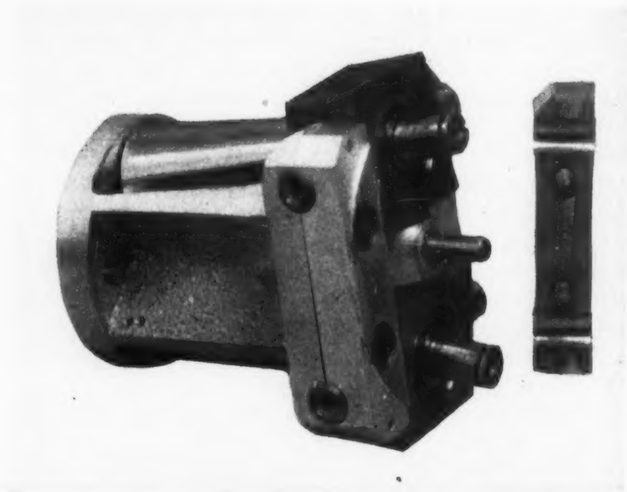


Fig. 4, the cam on the input shaft which applied a contact pressure between roller and ring proportional to the input torque, was replaced by a simple pillow block to give the desired loading through a *fixed* amount of centrifugal force plus, in some cases, an auxiliary spring. This had a further advantage over the previous torque-responsive loading in that it nearly doubled the torque capacity at low speeds (near zero) as compared to high, which is desirable in nearly all applications of variable speed drives whereas with the input cam loading the torque capacity decreased at low speeds, for reasons which need not be here explained, but are apparent by analysis of the mechanics involved.

This third design, with the roller carried by a fixed spherical bearing at its small end and a pillow block sliding in a guide in the carrier at its large end, appeared in units that were widely used during the war. Thousands were employed for the tracker drive on gun directors, airplane cameras, reproduction equipment, machine tool feeds, etc.

FOURTH DESIGN: But even this design, contrary to the popular delusion that inventions may spring Minerva-like in final form from their creator's cranium, was found to have one serious limitation or Achilles' heel (to continue the mythological allusion) that greatly curtailed its application. For a given dimension of housing, or ring bore, which establishes the size of the transmission, the rating was determined and restricted by the capacity of the spherical bearing. This is because the strength of the rollers and ring was inherently in excess of that of the spherical bearing, whereas an economical design, as every engineer knows, must approach the ideal of the "one hoss shay." Obviously, two bearings instead of the one could not be used here without abandoning the pivot. Therefore the next step, which required three years to perfect, was to work out a special and unique form of universal joint, *Fig.* 5, to replace the spherical bearing and permit the use of two larger, angular contact preloaded bearings whose capacity—particularly in thrust—was several times that of the single spherical bearing. In addition, the sliding pillow block was weighted at its outer surface to add to the centrifugal force.

These seemingly simple changes greatly extended the field of application of the drive by increasing the capacity for a given size. Conceivably the problem could then have been considered solved, except for the fact that the universal joint was an expensive part to make and in connection with the weighted pillow block at the large end of the roller still kept the cost per delivered horsepower at too high a figure.

FIFTH DESIGN: The next step was the discovery of a way to eliminate both the joint and the pillow block, decrease the number of parts, particularly the number of ball bearings, and add one-third to the capacity for a given size. All this cut the cost of the transmission by nearly one-half and was accomplished

(see *Fig.* 6) by replacing the universal joint with a "hinge" construction and eliminating the guide at the large end of the roller entirely. The omission of this guide was possible (this had not previously been realized) because the available traction coefficient in a lubricated drive is so low as to permit the tangential reaction at the ring contact to be fully supported, cantilever-fashion, by the same two bearings at the pivot, which share the radial load with the ring.

Instead of the universal joint, then, a bearing block carrying the two angular-contact, matched and preloaded bearings was hinged in the carrier, and since there was now no block at the large end of the roller, this not only eliminated two bearings for each roller at that point but added one-third to the effective length of the roller in a given housing, which in turn added one-third to the capacity. All this meant more power with fewer parts and less cost—a real advance.

Final Step Brought Biggest Gains

Now at last the designers might have been content to rest on their laurels. But the real denouement was yet to come, which was to add nearly 50 per cent more (on top of the previous gains) to the capacity of a given size transmission, replace a seven-piece roller carrier assembly by a single-piece carrier, give greater stability, quieter operation and still greater accuracy of speed holding and speed setting.

FINAL DESIGN: Up to this point all devices of this general type (and the patent files show a large list) had based the design of the roller mounting on the assumption, apparently a quite natural one, that in order for the roller to make pressure contact with the ring, it would have to be "flexibly" mounted in the carrier—free to "move up", so to speak. Hence, the use of axially movable bearings in the Graham first design, the spherical bearing in the second and third, the universal joint in the fourth and the hinge in the fifth. This flexibility in each case meant added structure, added parts, added cost—*and actually wasn't needed at all.*

It has already been explained that the radial centrifugal force of the roller in any event divides between the bearings at the small end of the roller and the ring (in proportion to the distance of the center of gravity of the roller assembly from the bearings and ring respectively). The ring, therefore, is really the counterpart of a bearing at the end of a shaft—but full use had not previously been made of this important fact.

It was finally realized that if the rollers could in the initial assembly be so positioned that each was in contact with the ring bore (no matter what the axial position of the ring), then the bearing at the small end of the roller could be locked in position in the carrier. Then, when rotation started, the centrifugal force would divide between bearings and ring as above explained, just as in the other designs. The initial positioning required merely a few shims of required thickness (see *Fig.* 8) inserted between the bearings and a shoulder in the inclined bore of the carrier. Yes, a few shims costing less than a cent took the place of joints, hinges, blocks, etc., and at the same time permitted a simple one-piece carrier to do the job of mounting. Too, this elimination of parts enabled a third roller to be introduced into the same size casting that previously could house only two, adding 50 per cent to the capacity of a given size transmission. Incidentally, the third roller gave other important advantages of improved quiet, still closer speed holding and speed setting, etc. But the big achievement was simplicity, low cost, and of course the added reliability that goes with fewer parts.

Here then was the obvious way to mount planetary rollers in their carrier in a variable speed transmission of the tractional type. But why the five detours?

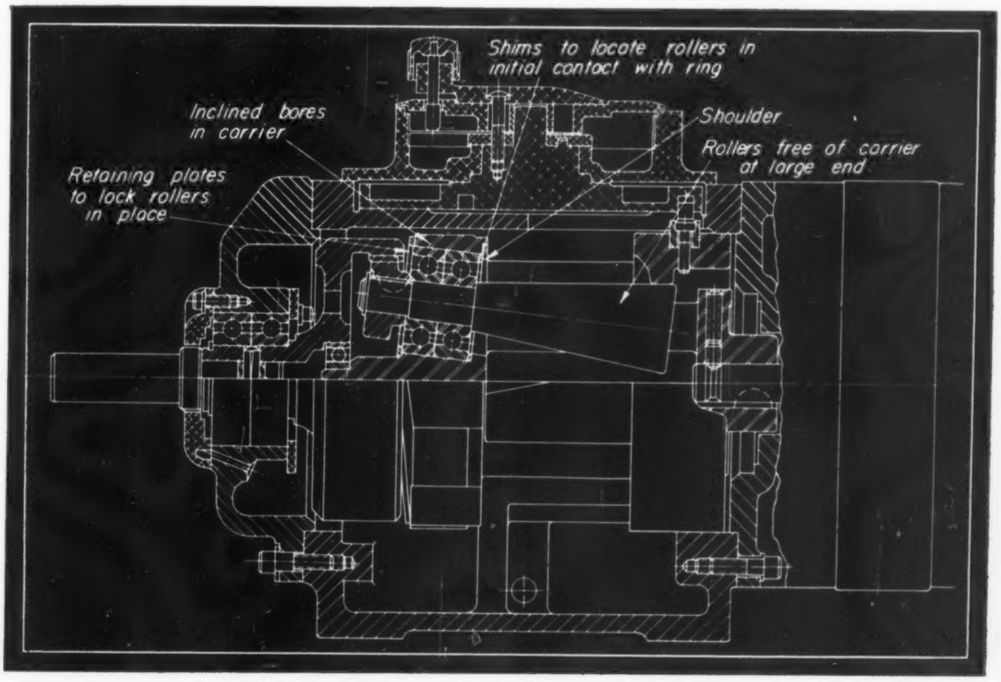


Fig. 8—In final design rollers are free at their large end. Bearings at small end are locked in position at assembly, after rollers have been brought into initial contact with ring by shims inserted in carrier

Fig. 1—Effective teamwork in progressive engineering department functioning can be achieved most successfully through properly organized development committees

A Plan for Engineering Am

To attain better engineering teamwork in the interests of improved products and more economical manufacture, a highly successful development committee plan is outlined

By Charles R. Sutherland
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MUCH of the success of an engineering department, as with any department, depends upon how capably it communicates with other departments. The absence of proper communication results in misunderstanding, stagnation, loss of time, and lack of team work.

The increased size of organizations and greater specialization creates a greater need for more effective communication or dissemination of technical data, *Fig.* 1. This is necessary in order to have a better understanding of the technical problems that are placed before the different departments within the manufacturing organization. It is equally important that the engineer should recognize the problems beyond his immediate province.

Without a doubt an engineering department is a "technical middleman." Generally speaking, it is a liaison department between sales effort and production processes. It translates and transforms customer requirements into plans. From these plans, then, the requirements can be manufactured; just how *economically* manufactured, depends greatly upon the effectiveness of the overall engineering co-ordination.

The engineering department also serves as a focal point, gathering information and also disseminating it. This is shown graphically in *Fig.* 2. From this chart it is evident that the engineering department receives requests for product designs, data, and other

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Amplishment

technical material from the sales department. In order to fulfill these requests, the department must draw upon its skill, knowledge and technical files. Sometimes outside assistance is required. The end result, of course, is a plan, design, or procedure which has to be transmitted to the various manufacturing departments. The machine designer or engineer spends the greater portion of his time communicating with others in order to properly accomplish this purpose or end result.

In addition to letters, telephone calls and telegrams, the engineer uses drawings, specifications, instructions, conferences, and meetings in order to put his ideas into effect. Is the answer to more effective communication and understanding, more letters, drawings and specifications? Or, will the increased volume of correspondence, drawings and specifications tend to find them buried in desk drawers? There must be a better solution than to increase the amount of paper work.

Product Development Committee an Answer

Because modern business is not an individual venture it should not function as an individual but as a team. Therefore, it is logical that a progressive engineering department should work as a team with other departments. Working as a team, the other departments should be called in and advised on impending designs and should be asked for constructive criticism. An organized method to secure such cooperation is through a recognized committee, perhaps a product development committee, *Fig.* 1.

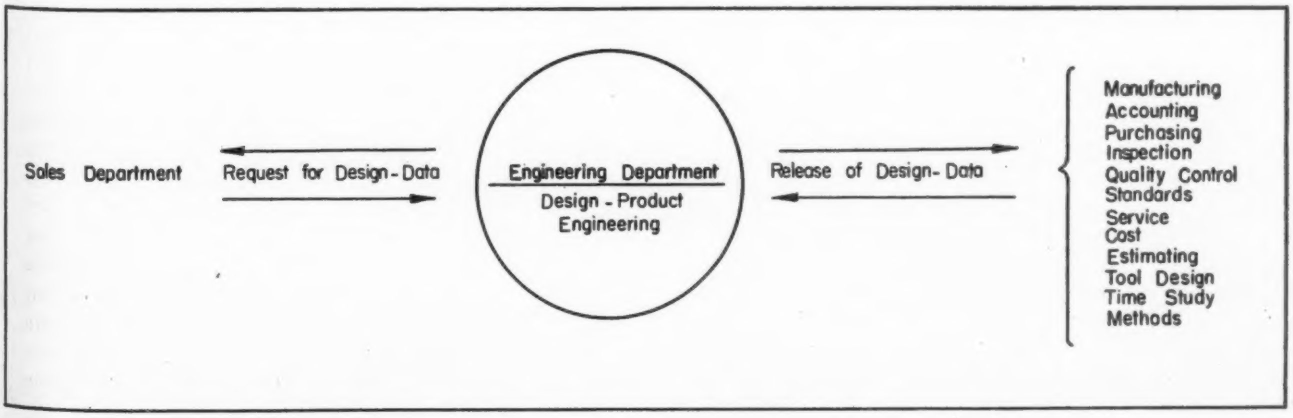
Committee meetings are not new. They differ from conferences in that at a committee meeting definite recommendations are made and acted upon. The strongest appeal for committees in an organization is that it creates a source of experienced counsel and talent to solve problems involving heterogeneous activity. The further advantage of a committee is that once a policy is established, or a decision is reached, it has withstood the cross-fire of criticism or opinion and usually will go into effect without too much difficulty.

In order for a product development committee to function smoothly and successfully it should possess some character and recognition. The following factors should be taken into serious consideration in organizing such a committee:

1. Purpose of committee should be understood
2. Selecting the chairman of a technical committee from the engineering department is desirable
3. Members should be selected with care
4. Subject matter for meetings should be appropriate
5. Meetings should be well planned
6. Follow-up on decisions and recommendations should be made.

For a committee to progress well, it should have

Fig. 2—Schematic layout showing the place and activity of the engineering department in an organization



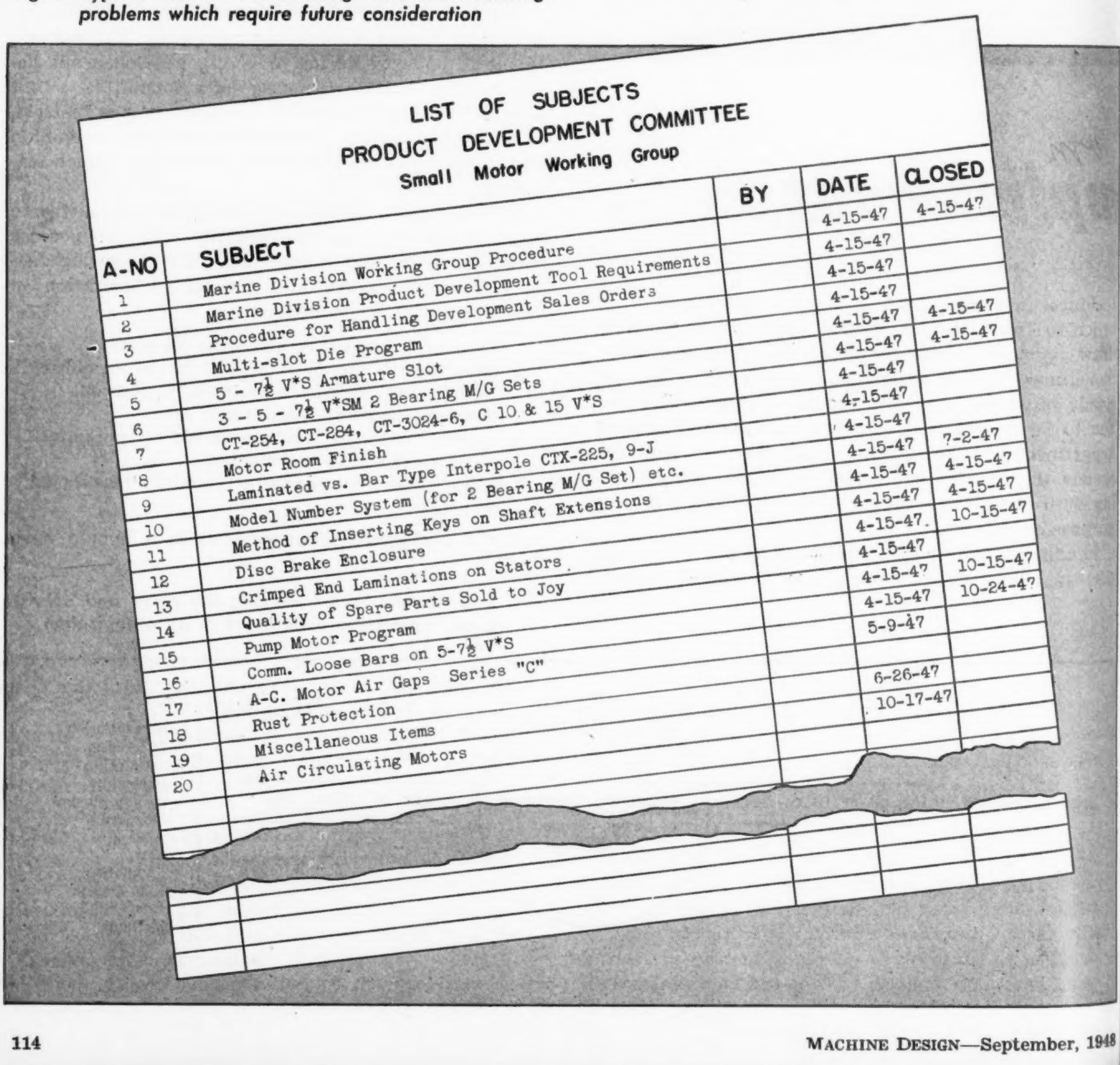
the enthusiastic interest of every one who participates, particularly the executive management. To give the group responsibility for its action and performance is excellent. A well-defined purpose for the committee is necessary so that it will not become a catch basin for all types of problems for which the committee is not equipped to cope. A means should be provided to the committee for the handling of problems that cannot be settled with any degree of satisfaction. The top management should recognize this and accept such problems as part of their ex-officio relations with the group. Conversely, top management should also recommend to the committee certain courses to follow.

A technical committee should be headed by an engineer or an individual with technical background. Because the problems set before such a committee will be technical by nature it is important that they be fully understood by the chairman. Then too, since the technical development lies within the engineering department, it is logical that the chairman, who is part of the engineering organization, recognize the need for committee action. A chairman should possess the same characteristics that are found in any leader plus understanding of the specific problems set before him, anticipation of difficulties and keen enthusiasm for the committee.

The committee members should be selected for what they can contribute by their presence and knowledge. Too often a committee is selected at random by merely inviting all personnel having the same level of authority in an organization. This is in error because much basic detail information, needed for final decisions, is often to be found in an individual who has a rather obscure position. There is also the tendency to invite higher executives to become members on the assumption that the committee will gain prestige. A committee is more effective if it has proper representation from all the departments who will be affected by the decisions and policies promulgated by it. The selection of members can be considered good if they possess the following qualifications:

1. They must represent their department's interest

Fig. 3—Typical docket index of design and manufacturing problems which require future consideration


LIST OF SUBJECTS
PRODUCT DEVELOPMENT COMMITTEE
Small Motor Working Group

A-NO	SUBJECT	BY	DATE	CLOSED
1	Marine Division Working Group Procedure		4-15-47	4-15-47
2	Marine Division Product Development Tool Requirements		4-15-47	
3	Procedure for Handling Development Sales Orders		4-15-47	
4	Multi-slot Die Program		4-15-47	
5	5 - 7½ V*S Armature Slot		4-15-47	4-15-47
6	3 - 5 - 7½ V*SM 2 Bearing M/G Sets		4-15-47	4-15-47
7	CT-254, CT-284, CT-3024-6, C 10 & 15 V*S		4-15-47	
8	Motor Room Finish		4-15-47	
9	Laminated vs. Bar Type Interpole CTX-225, 9-J		4-15-47	
10	Model Number System (for 2 Bearing M/G Set) etc.		4-15-47	7-2-47
11	Method of Inserting Keys on Shaft Extensions		4-15-47	4-15-47
12	Disc Brake Enclosure		4-15-47	4-15-47
13	Crimped End Laminations on Stators		4-15-47	10-15-47
14	Quality of Spare Parts Sold to Joy		4-15-47	
15	Pump Motor Program		4-15-47	10-15-47
16	Comm. Loose Bars on 5-7½ V*S		4-15-47	10-24-47
17	A-C. Motor Air Gaps Series "C"		5-9-47	
18	Rust Protection			
19	Miscellaneous Items		6-26-47	
20	Air Circulating Motors		10-17-47	

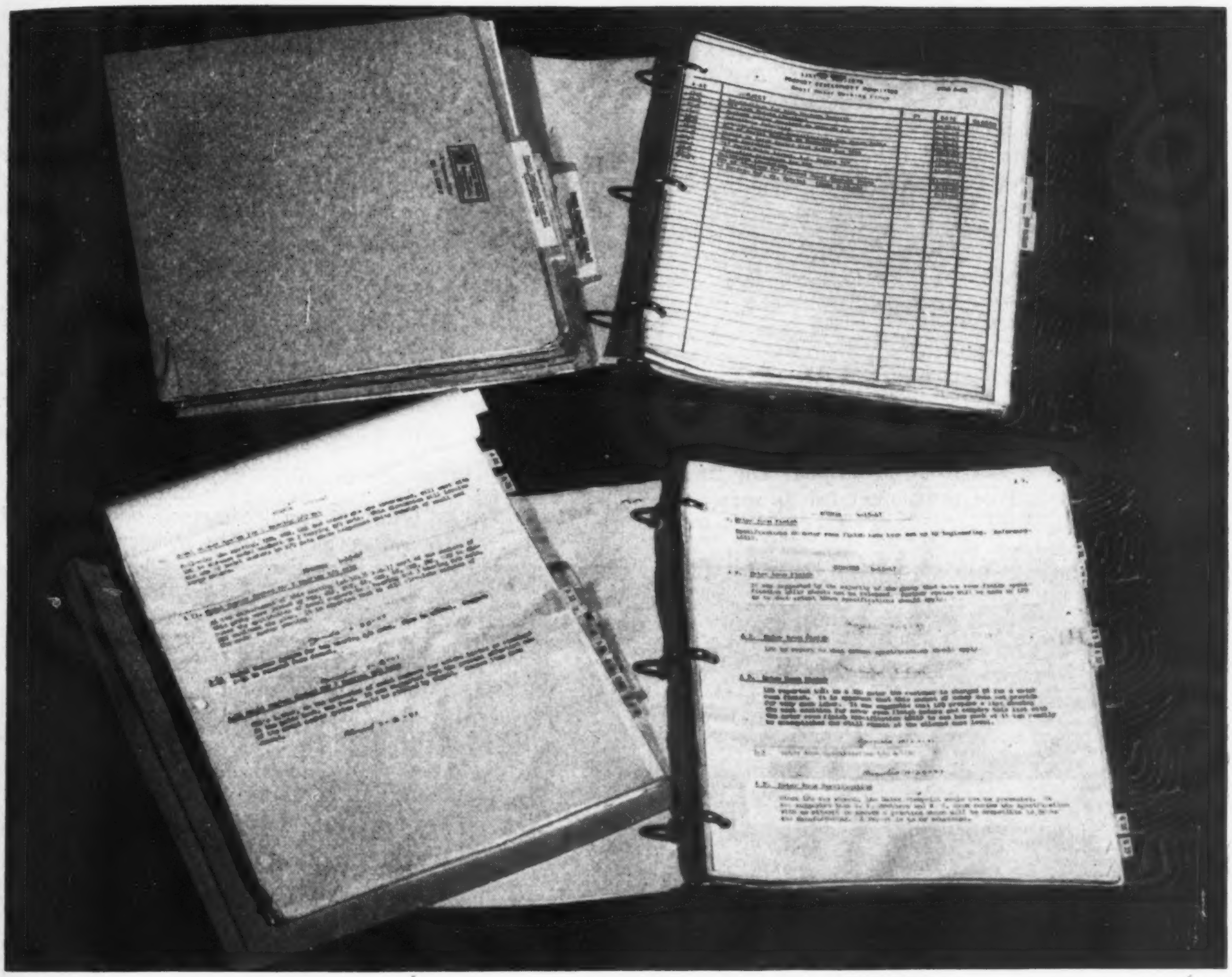


Fig. 4—Suitable records and files of pertinent information relative to committee operation and action are a must

and consolidated viewpoint

2. They must have a concise knowledge of their department
3. They must be able to recognize how a decision will affect their department.

While the kind of subject matter dealt with can be well regulated by the chairman, there is much danger of a wide range of subjects creeping into the committee docket. This happens if the members, or the executive officers, have failed to recognize the responsibility and scope of the problems that the committee is to cover. To illustrate the point: A product development committee is about to review a newly designed hoisting mechanism, which is about to go into production. A member, the factory manager, notes that the design will require a revision of his machine tools. Questions on the hoist which will eliminate such a revision certainly are in order. However, questions on how the revision of the machine tools shall be made, are out of bounds as far as the committee is concerned, unless the committee agrees to consider it as part of its responsibility. Time and a number of meetings usually set the pattern for the type of organizational problems that are to be settled before the group.

Many committees function without recognizing the need of extensive preparation for the meetings. Details can eat up valuable committee meeting time. It is up to the chairman to review the docket and prepare an agenda. However, this is not always sufficient. Problems should be studied in advance and charts, tables and other data accumulated, compiled and digested into a form that can be simply followed by a group.

Lack of follow-up on decisions and recommendations is a time waster. If a decision is made it is necessary that the proper individuals or departments involved are duly informed. If more information is required for the following meeting, it is necessary that some one assume responsibility for furnishing it. A committee's decisions are put into action by correct follow-up of memos and instructions to individuals and departments that are affected.

The place for the meeting should be such that it will be conducive to a well-regulated session, not crowded or noisy. A large table for spreading out drawings is a convenience. A blackboard is a must.

Co-ordination of Paper Work

There are certain mechanics required to carry on a committee function, particularly over a long period,

and these mechanics deal with the most efficient way of co-ordinating the paper work, which is inevitable. The careful keeping of records adds to the prestige and effectiveness of the committee. A planned procedure in the handling of paper work makes it less difficult to put into action the decisions and recommendations made at the meetings. The minimum handling of paper work necessary can be listed as follows:

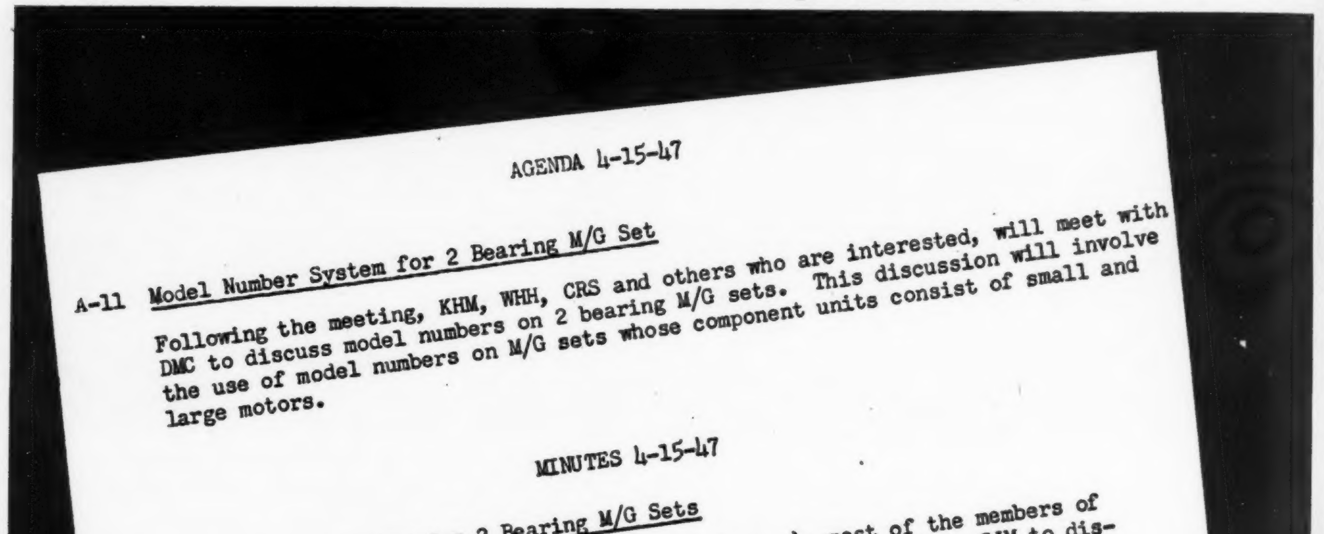
1. Notice of meetings
2. Agenda
3. Minutes
4. Docket
5. Subject file.

A formal notice of a meeting is essential, and should be issued enough in advance to enable members to be present and to be prepared. The time for the meeting should be convenient for as many members as possible. The meeting should be limited to a definite length of time so that members can make their plans to fit with the meeting time.

Prior to the meeting the chairman should issue an agenda covering the items which will be up for discussion. The subject matter on the agenda is usually the result of a number of factors: (1) Urgency of the problem, (2) decision that may need group consideration, or (3) usual order of business on docket. The agenda need not be long, but it should be clear as to what will be up for discussion, and what plans will need to be made. If certain members are to report, it is usually well to state who will present the problem.

Minutes of each meeting should be kept. They should be clear, accurate, and sufficiently complete

Fig. 5—Typical file sheet carrying agenda and minutes of meetings for reference regarding committee action


AGENDA 4-15-47

A-11 Model Number System for 2 Bearing M/G Set

Following the meeting, KHM, WHH, CRS and others who are interested, will meet with DMC to discuss model numbers on 2 bearing M/G sets. This discussion will involve the use of model numbers on M/G sets whose component units consist of small and large motors.

MINUTES 4-15-47

A-11 Model Number System for 2 Bearing M/G Sets

At the adjournment of this meeting (at 10:35 a.m.), most of the members of this group were joined by PWA, JLF, FRT, AS, GAS, CT, CRN, DMC, CJM to discuss the application of model numbers to 2 bearing and 3 bearing M/G sets. DMC outlined the plan. It is expected that he will circulate minutes of the model number meeting.

AGENDA 6-30-47

A-11 Model Number System for two bearing M/G sets. Plan in effect. Suggest A-11 be removed from docket.

MINUTES 7-2-47

A-11 Model Number System for 2 Bearing M/G Sets

DMC's letter, on the extension of model numbers for motors listed as standard in the price book, was read. It was suggested that the present effective use of the model number system should be studied by Tippit. Remove item from docket.

CLOSED 7-2-47

so that they can be referred to with confidence. Who keeps the minutes is not so important as what goes into them. All recommendations and particularly matters that require follow-up should be recorded.

Even a successful committee cannot settle all the matters and problems that they have before them in one short meeting. Therefore, a docket is required to list the matters that need future consideration, *Fig.* 3. Certain elements must be shown on a docket: (1) Identification of subject. A docket number is more rapidly identified than a statement of an entire subject; (2) statement of the subject; (3) name of department or individual who submitted the problem; (4) date when submitted; and (5) date when subject was removed or closed.

In the course of settling a matter at hand, a good deal of correspondence will be issued. Therefore, a suitable file for the subject under consideration should be maintained, *Fig.* 4. The file heading can carry the same information as used on the docket. In addition to that, it is very convenient to have a sheet in front of the file to which is pasted, in chronological order, the agenda and minutes of the meetings in which the subject was discussed, *Fig.* 5. This sheet serves as a very expedient device, especially to the chairman, who must often answer questions regarding past activity.

The chairman should have all of the above records available and in such a form that quick reference can be made. As an aid to quick reference, the material can be conveniently filed in the following categories:

1. Docket and subject reference
2. Notice of meeting, agenda and minutes
3. Completed and closed-out file
4. General committee correspondence (that cannot be logically filed under subject reference).

Further simplification in the record keeping can be accomplished by pasting the agenda and minutes referring to each subject in front of each subject file in chronological sequence. This gives the chairman a quick means of checking the past activties on each subject.

What a Committee Should Accomplish

The accomplishments of a product development committee are manifold, but the laconic answer could well be that it only achieves what it sets out to do. In addition to the recognized function of the committee, certain other psychological factors are in play which cannot be escaped. Designs and recommendations are more acceptable to the members who have participated in their formulation. This is true, partly because they understand their importance and partly because they were aware and cognizant of the events that made them a necessity. Another psychological truism is that group thinking is more productive than that of individuals working as a team through the media of memos and letters.

The committee's greatest apparent value lies in its solution of company problems by a group having concentrated knowledge and experience. As a result of such thinking power, redesign changes should be at a minimum. Designs, after they are reviewed by this group, should be the most satisfactory to the organization from sales, manufacturing and engineering viewpoints.

One of the greatest values in a committee is in its effective liaison between engineering and production. It is the best all-around means of keeping all departments in phase with what is going on in the engineering department.

Committee function has been criticized from a number of angles, perhaps rightfully so. Committee participation means cost—if the time of highly paid personnel is taken into consideration—and doubly so if the committee does not perform efficiently. Another criticism is that good ideas and suggestions get bogged down in committees. The faults usually found with committee work, and there are many, need not necessarily condemn it; but the faults do point out the pitfalls that should be avoided when setting up a committee.

Summarizing, in short, some of the salient factors on product development committees. It is the most democratic and effective way of designing within an organization. Certain factors need be taken into consideration to form a successful committee. Proper paper work co-ordination is recommended. The committee should make the design more readily acceptable to the entire organization with fewer changes and low cost. Criticism of committees should be a warning for what to avoid.

C. R. SUTHERLAND served as chairman of an engineering committee formed to investigate a new line of equipment to be manufactured at Reliance. His experience in this work and at present as chairman of the small motor product development committee has confirmed his estimate as to the practical value of such engineering co-ordination.

Following his first work in electric-motor design at Apex Electrical Mfg. Co., he joined the Reliance Electric & Engineering Co. in 1939 as mechanical designer. During the war he served as engineer in charge of Plant 2 and chief draftsman, respectively. He was named mechanical engineer in charge of development in 1946 and head engineer in charge of small motors in 1947.

A native of Cleveland, Sutherland "co-oped" at Bailey Meter Co., 1929 to 1934, receiving his B.S. in mechanical engineering at Fenn College in 1935. Having received his B.S. in industrial engineering in 1940, he followed up with graduate work at Case Institute of Technology.

How To Design

Pressure Moldings

By James L. Erickson

Dayton, Ohio

BECAUSE of their superior mechanical properties, pressure-molded aluminum-alloy parts are currently being employed to replace parts formerly made as gray iron and malleable iron sand castings, heat-treated light-metal permanent moldings or sand castings. Pressure moldings now compete favorably with a wide variety of fabricated and cast metal parts. In order that the designer may appreciate the qualities of pressure moldings, he should be cognizant of the advantages and the limitations of the two parents—die castings and permanent-molding castings.

Die Castings: The advantages of die castings from a machine designer's standpoint are that they:

1. May be cast to close dimensional tolerances, requiring little or no machining
2. Can be cast with extremely smooth surfaces which require little subsequent surface finishing to prepare them for plating or painting
3. Can be produced at a high production rate
4. Can be cast with most of their required holes
5. Possess extremely uniform dimensions from casting to casting
6. Can be cast when of complex design and shape
7. Can be cast with very thin walls
8. Can be obtained in alloys which possess from good to high corrosion resistance
9. Can be obtained in sizes ranging from a fraction of a pound to over ten pounds
10. Can be produced with inserts cast integrally
11. When required in large numbers, can be obtained at a tooling cost which is less than that of most competing processes.

Combining the desirable characteristics of aluminum alloy die castings and heat-treated permanent moldings, pressure moldings manifest superior mechanical properties in the as-cast condition and can be raised to elevated temperatures, such as for solution heating, without blistering or distorting. How to design parts to be made by pressure molding (Army Air Forces Specification No. 11347) is discussed from the viewpoint of mechanical properties

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On the other hand, the limitations of ordinary die castings from the designer's standpoint are:

1. Their design excludes undercuts
2. They frequently possess internal, trapped gas porosity
3. They frequently are host to cold shuts
4. They generally possess a heterogeneous microstructure and macrostructure
5. At best their mechanical properties are less than those of heat-treated permanent moldings
6. They exhibit a serious lack of ductility
7. They exhibit comparatively low fatigue and impact strengths
8. Their mechanical properties in tension and compression are inferior to those of heat-treated permanent molded castings

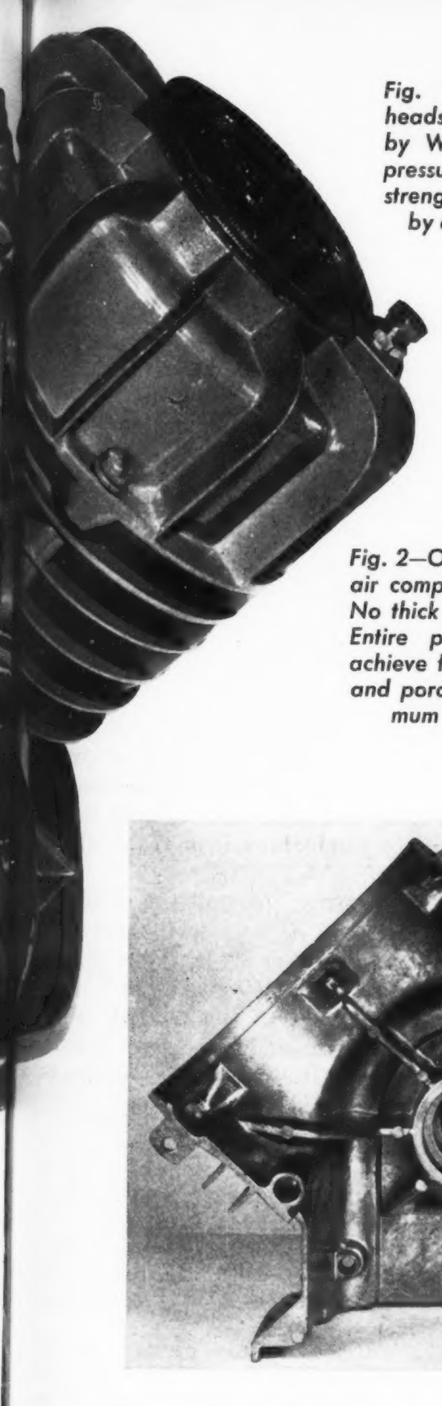
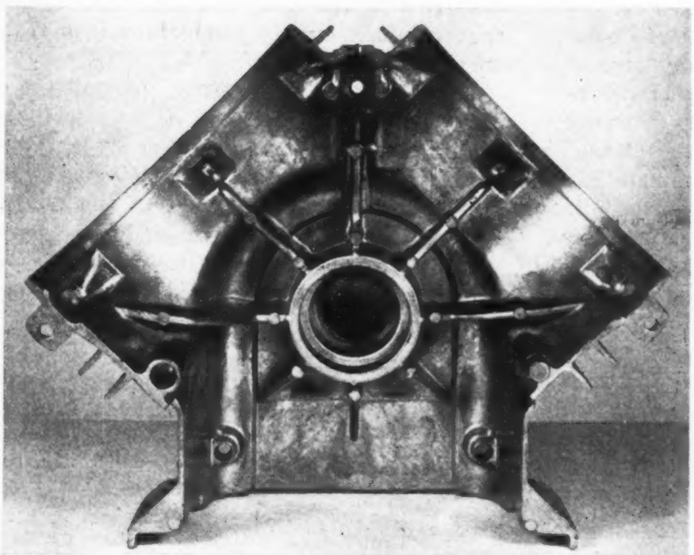


Fig. 1—Body and cylinder heads of this compressor built by W. R. Brown Corp. are pressure molded. Maximum strength has been assured by avoiding thick sections

Fig. 2—One-half of body for the air compressor shown in Fig. 1. No thick sections are employed. Entire part was designed to achieve freedom from shrinkage and porosity and to have maximum mechanical strength



9. They blister and distort dimensionally on heating to elevated temperatures, thus preventing their successful heat treatment
10. Their mechanical performance may vary widely from casting to casting
11. They cannot readily be obtained in certain desirable aluminum base alloys
12. They possess different mechanical properties in different sections of the same casting.

Permanent-Mold Castings: Permanent moldings of aluminum alloys possess one very attractive characteristic from the designer's standpoint: They have uniform mechanical properties from casting to casting, and from section to section within the same casting. They also possess good mechanical properties, are free of internal trapped-air porosity, are free of cold shuts, exhibit a homogeneous macrostructure and microstructure, and can be successfully heat treated without blistering or distorting dimensionally.

Their limitations as compared to die castings are: Their walls cannot be cast as thin, their dimensional tolerances cannot be held as close, their surface finish is not as smooth, and they cannot be as extensively cored.

Pressure Moldings

Pressure moldings manifest nearly all of the desirable characteristics of die castings and heat-treated permanent moldings, while at the same time they are free of the principal disadvantages. They are characterized in part by:

1. Smooth surfaces
2. Sharp definition
3. Freedom from cold shuts
4. Freedom from internal trapped air porosity
5. Homogeneous microstructure and macrostructure
6. Excellent corrosion resistance
7. Light weight
8. Superior mechanical properties.

The pressure molding process readily produces castings of intricate structure having extensive coring and thin walls, *Figs*. 1 and 2.

Very close dimensional tolerances can be held, and consequently pressure molded parts, like die castings, require little if any machining prior to their assembly into a given machine.

Most attractive design characteristics of aluminum alloy pressure moldings are their: (a) excellent ductility, (b) high endurance strength, (c) high impact strengths, and (d) superior yield strength in tension—as contrasted with ordinary aluminum alloy die castings, Table I.

Mechanical Properties: Table I gives the mechanical properties of contemporary aluminum alloy pressure moldings the most beneficial of which is extremely good ductility. In the die-cast state, Alcoa Alloy No. 13 seldom manifests over 3 per cent elongation (actually some specifications call for only 1.8 per cent). In the pressure-molded state this same alloy exhibits between 8 to 10 per cent elongation, Table I. Other notable improvements in the mechanical properties of the common die casting alloys when pressure molded are exhibited in connection with their superior impact strength and endurance strength.

Pressure moldings are the outgrowth of a considered study of the origin of the undesirable qualities and irregularities of die castings and permanent moldings. Today, for example, the origin of internal porosity in die castings is understood and recognized to be the result of the entrapment of air which is prevented from escaping from the die cavity through the air vents provided, and which, because it is insoluble in molten aluminum alloys, remains to form the un-

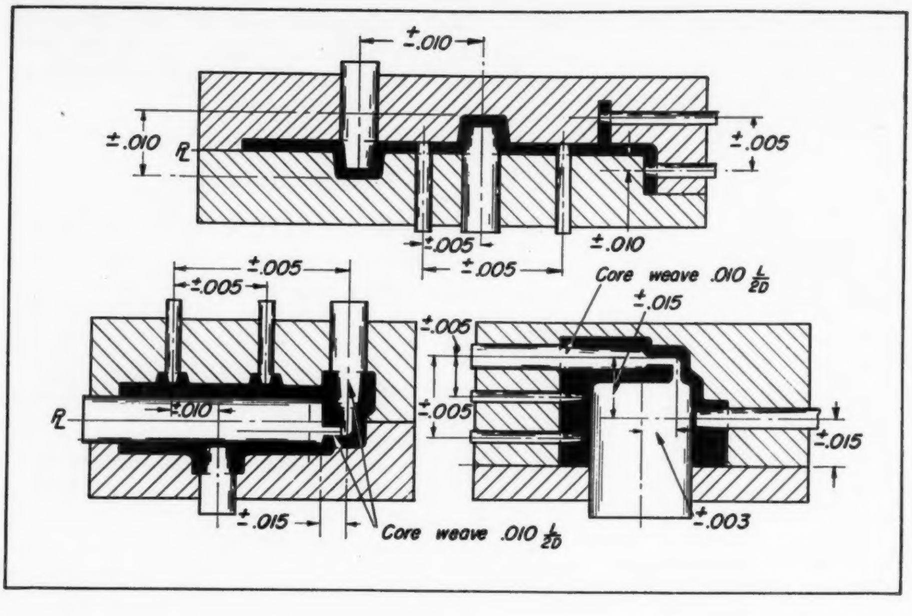


Fig. 3—Diagrammatic sketch showing dimensional tolerances that can be maintained between various points within a pressure molding die (drawing, courtesy H. L. Harvill)

desirable porosity in the castings.

In pressure molding, special care is taken to design the mold so as to permit the influx of molten casting metal to wash through the die cavity into large overflows and to carry with it the air normally present within the die cavity— air which would otherwise be *trapped* within the main die cavity. The extensive use of overflows plus close adherence to the "wash" principle has a beneficial effect on the ultimate mechanical properties of a pressure-molded part through the creation of a homogeneous microstructure free of trapped air porosity and cold shuts, and characterized by extremely fine eutectic in the case of the aluminum-silicon alloys.*

The superior properties of pressure moldings result from the fact (1) that the pressure moldings are almost entirely free of internal, trapped air porosity, (2) that pressure moldings are made from comparatively impurity-free alloys, and (3) that their microstructure is (alloy for alloy) superior to that of die castings. This condition is traceable to the fact that during the filling of the pressure molding die cavity turbulence is held to minimum, while in the case of the die casting the metal is subjected to violent turbulence not only as it fills the die cavity but even as it is solidifying within the die cavity.

Designing for Pressure Molding

To obtain the greatest benefits from pressure moldings, the machine designer should bear the following rules and principles in mind when designing parts to be pressure molded. While these rules and principles have exception in special cases, in most instances they apply.

OVERALL SHAPE OF THE PRESSURE MOLDING: Simplicity of design, effected without restricting the function for which the part is intended, is prerequisite to inexpensive die construction as well as to the attainment of pressure moldings with superior mechanical properties. For example, it should be realized that surfaces of rotation are easiest to machine when constructing the dies, and it is wise to bear in mind that complex curves and contours increase die cost considerably.

DIMENSIONAL TOLERANCES: Not all the dimensions of a pressure molding can be held to the same close limits due to the nature of the pressure molding die, shrinkage of the pressure molding alloy, etc. *Fig.* 3 gives the designer a picture of the relation of part dimensioning to die design and the tolerances it is possible to guarantee. With regard to tolerances a few specific rules are listed:

A Dimensional Tolerances

1. Minimum tolerance on close dimensions is ± 0.0015-inch per linear inch but not less than ± 0.002-inch on any dimension
2. Fractional dimensions up to seven inches have a tolerance of ± 0.010-inch; over seven inches the tolerance is based on ± 0.0015-inch per linear inch
3. Dimensions affected by the parting line or other moving parts of the die have an additional tolerance—sometimes as much as 0.010-inch

B. Flatness Tolerances

1. By multiplying the longest dimension, such as across corners, by 0.0015 the approximate flatness tolerance in thousandths of an inch will result. Example: A surface approximately seven inches across its longest dimension would have a tolerance of 7 x 0.0015 = 0.010-inch measured on a surface plate

C. External Thread Tolerances

1. External screw threads having rather broad tolerances can be cast in coarser than 24 per inch and if located on a part in such a position as to make casting practical. The required tolerance for any cast thread should be secured from the die casting engineer.

SECTIONAL VARIATION: To insure the desired mechanical properties in a pressure-molded part, it is absolutely essential for two reasons to pay close at-

* A discussion of the theory of "overflow" use is to be found in a forthcoming issue of *Light Metal Age*.

Fig. 4 — Right — Pressure-molded parts produced on a large H.P.M. cold-chamber injection machine. Each part possesses one or more of the following properties: pressure tightness, high fatigue strength, high tensile strength, or very sharp definition

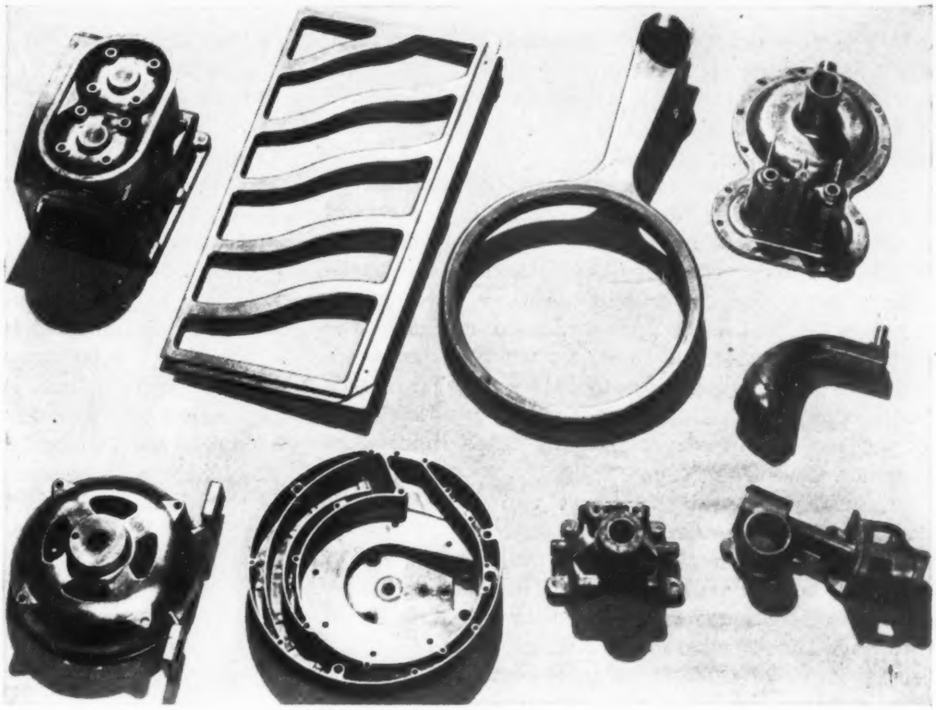
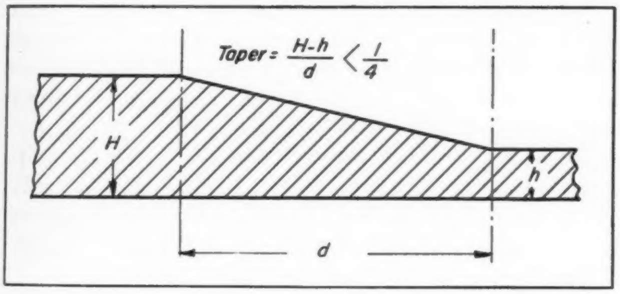


Fig. 5—Below—Wedge design for joining thick and thin wall sections in a casting



tention to the design of the sectional variation. Proper sectional design decreases the possible formation of shrinkage porosity and reduces the formation of undesirable internal stresses. This is particularly important when designing pressure moldings which are to be of the aluminum-magnesium base alloy type.

All cross-sections of a proposed pressure molding, especially at points where its sections join, or are the thickest, must be assured a sufficient supply of liquid metal during the solidification period if the formation of cavities and porous areas are to be prevented by the transmission of the applied injection pressure. The isolation of heavy cross-sections, or disposition in parts of the casting where they cannot be adequately supplied with liquid metal, has particularly damaging effect on the quality of the pressure molding.

The sectional design of a pressure molded part must allow for shrinkage, as well as the checking of shrinkage, caused by mechanical and thermal factors. In order to prevent excessive shrinkage or "mechanical" stresses, pressure moldings should be of such a design as to allow for free contraction once they are removed from the die. To prevent the formation of "thermal" stresses, the design should enable all cross sections to cool as uniformly as possible. It is

TABLE I

Physical and Mechanical Properties of Pressure-Molded Aluminum Alloys

PROPERTIES	ALLOYS*				
	A43	A13	A360	A380	218
Yield Strength, Tension (Set 0.2%) (psi)	16,000–18,000	33,500–36,000	33,000–35,000	35,000–37,500	24,500–25,000
Ultimate Tensile Strength (psi)	33,000–35,000	44,500–46,000	45,500–47,500	45,000–46,500	44,000–47,000
Elongation, (% in 2 in.)	15–18	9–11	10–12	7–9	8–10
Charpy Impact (¼ x ¼ in. bar) (ft-lb)	6.5–8.0	5.5–7.0	5.0–6.5	5.5–7.5	11
Specific Gravity	2.70	2.68	2.66	2.76	2.53
Weight (lb per cu in.)	0.097	0.097	0.096	0.099	0.091
Shearing Strength (psi)	26.000	36,000	31,000	38,000	31,000
Melting Point (Liquid temp.) (F)	1,165	1,110	1,065	1,090	1,160
Thermal Conductivity (cgs units)	0.34	0.35	0.37	0.26	0.24
Thermal Expansion (in./in./C)	.000022	.000021	.000020	.000020	.000024
Electrical Resistivity (microhm.-cm.)	4.8	4.7	4.4	6.5	7.1
Endurance Limit (psi)	23.400	24.600	24,500	25,500	

* Aluminum Company of America alloy designation numbers. These alloys must be of the very purest variety, viz., iron in excess of 0.6-0.8% in A43, A13, A360, and A380 is not permissible.

well for the designer to remember that the internal stresses which are set up within a pressure molding during its solidification and subsequent cooling periods are proportional to the modulus of elasticity of the alloy being cast.

The chief prerequisite for obtaining pressure moldings free of defects or internal stresses is a design which employs a gradual tapering of sections and which avoids sharp angles, *Fig.* 4. Sharp changes in the sections of walls from one thickness to another are not permissible. The correctness of the proportions of adjacent cross sections may be checked by

the method of inscribed circles. When the change in thickness is less than 1:2, it should take the form of a fillet; where the difference is greater, the form used should be that of a wedge. Wedge-shaped changes in wall thickness are to be designed with a taper not exceeding 1:4, *Fig.* 5.

Cross-jointed walls (ribs) should be designed as double T-forms, *Fig.* 6. Sharp inner angles should be avoided, as these form a focal point for the accumulation of local stresses. Acute angles are particularly dangerous in designs as they become the seat for fatigue failure. In order to minimize the mass of metal in those locations where a perpendicular strengthening rib meets two walls, the design should allow for an opening in the rib which does not weaken the construction—this tends to produce a sounder pressure molding.

Uniformity of wall thickness can frequently be achieved by the intelligent use of cores or "metal savers" situated in those areas where walls might otherwise become unduly heavy. These metal savers serve two functions: They equalize the wall thickness and afford substantial reductions in the part weight. Each of these is valuable because a speedier cooling rate is insured, thus permitting a faster molding operation.

FILLETS: Proper fillets and corner radii must be employed if the pressure molding is to exhibit maximum mechanical strength properties. The formula:

$$R = \frac{A + B}{3}$$

where R equals radius of fillet, A equals wall section, B equals adjoining wall section, should be employed to calculate the proper fillet radius.

The machine designer should always use generous fillets wherever possible in designing pressure mold-

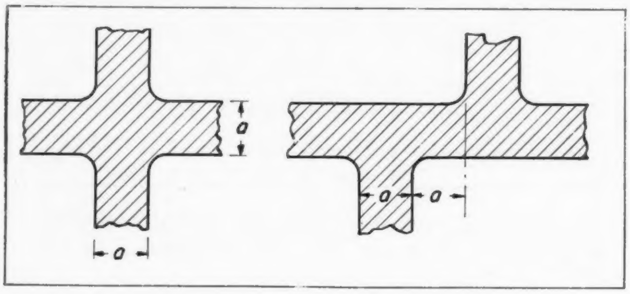


Fig. 6—Correct and incorrect designs of all joints

ings, for liberal fillets decrease die cost, eliminate drag marks as the pressure molding is withdrawn from the die, improve molten metal flow, reduce the progression of any possible heat checking of the cavity face of the casting die which usually originates at sharp corners, facilitate the rapid ejection of the pressure molding from die, decrease finishing costs, insure desirable metal structure at corners and junctions, improve the structural strength of the part, and frequently make for better part appearance. Actual sharp corners should never be used, the minimum fillet desirable being 0.015-inch, and larger fillets being used when their presence can be tolerated. As a general rule: Too little radius will lead to the heat cracking of the die, and too much radius will cause shrinkage at the junction of the sections and surface imperfections on any flat surface opposite the junction of the sections.

It is desirable to round all exterior corners except where a corner falls on the parting line of the die. Sharp corners on a pressure molding call for sharp corners in the die, and when these are present other than on the parting line their presence substantially increases the construction cost of the die because it is frequently extremely costly, if not often impossible, to sink a sharp corner. Consequently a sharp corner must be hand formed. As already mentioned, pressure moldings with sharp corners have a greater tendency to stick in the die, thereby slowing up the molding cycle, which has the effect of increasing the piece price.

Problems of Sharp Corners

Even though satisfactorily produced, sharp corners on pressure moldings are subject to damage from nicking or defacing during their subsequent handling and impose a more difficult buffing problem in cases where the pressure moldings are to be polished and plated than do pressure moldings with rounded corners. It is therefore superior design practice to radius all exterior corners not less than 1/16-inch; however, when sharp corners are essential for some special reason, they can frequently be formed; nevertheless, they should at least be "broken". Radii on the edges of ribs and webs should also be as generous as possible; in fact, a full radius is often desirable.

If a high order of surface finish is specifically called for, it is essential to employ ample fillet and radii, since surface finish is largely dependent upon the smooth flow of the molten metal into the farthest extremities of the die cavity.

FLATNESS: Large flat surfaces are best avoided as they are too frequently the cause of unwarranted rejections. In the event that large comparatively flat areas are called for, viz., in the case of some phonograph turntables, it is wise to resort to the use of stripping, crowning or curving. This will tend to insure the production of a pressure molding with a minimum of surface imperfection.

SURFACE IMPERFECTIONS: The designer must expect that a pressure-molded part will evidence slight imperfections, known as "shadow marks", on smooth or flat surfaces in regions where heavy ribs, bosses, or other thick sections join a thin section. To avoid the occurrence of this defect, the designer must keep the wall thickness of the pressure molding above 0.100-inch and/or the thickness of the joining or adjacent bosses, ribs, or studs to a thickness not exceeding 80 per cent of the wall thickness of the smooth area.

In the event that neither of these stipulations can be fulfilled, the occurrence of the surface imperfections can be avoided through the use of external de-

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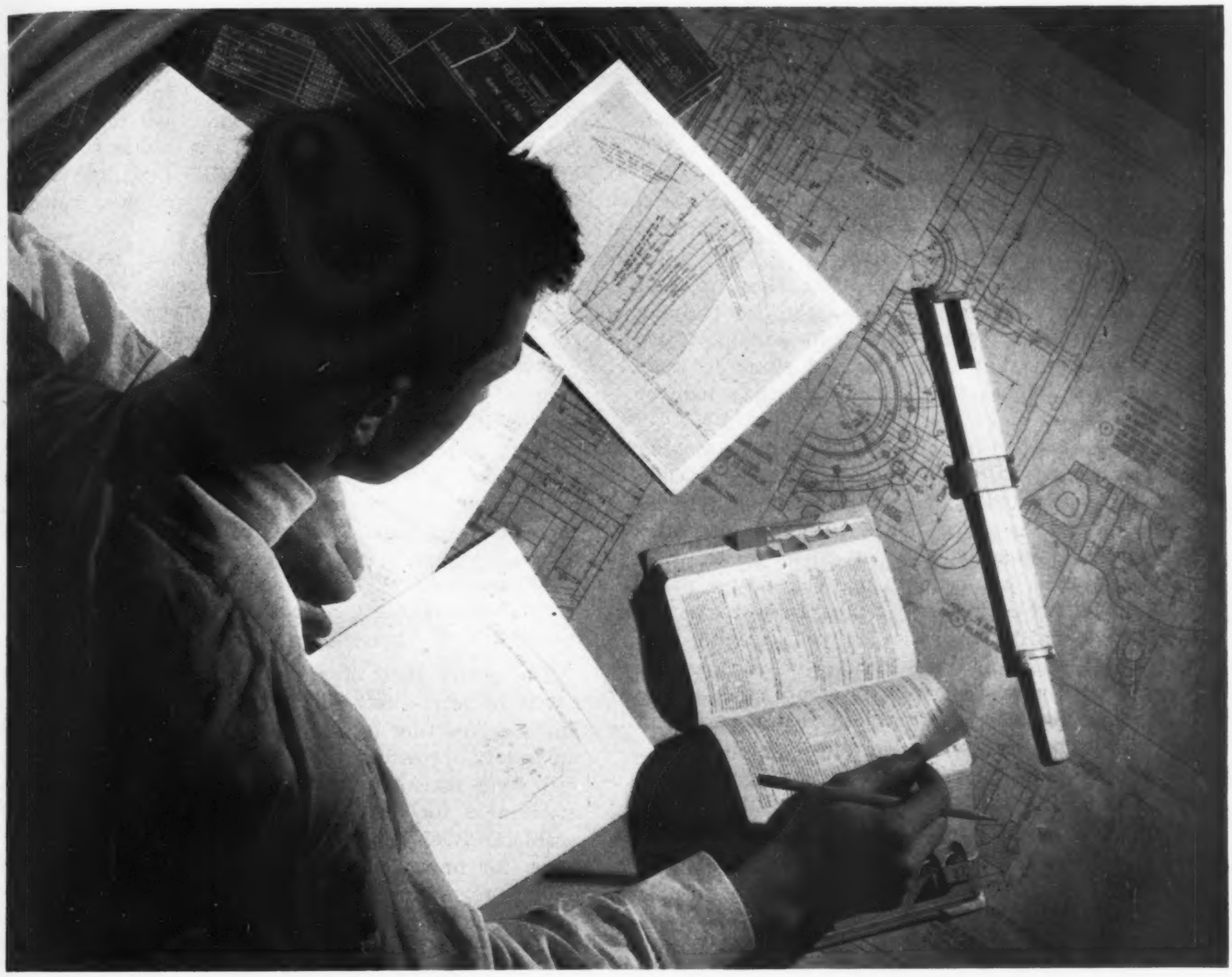


Potential capacities of the graduate soon develop into actual skills when training in industry is realistic

Engineering Education

. . . is joint industry-university responsibility

By Walter P. Schmitter
Chief Engineer
The Falk Corp.
Milwaukee, Wis.

THERE are compelling reasons that should prompt industry to seek more fruitful relations with the technical school or university. The engineer—in design primarily and in manufacture secondarily—establishes economic bases which, if unsound, endanger the whole corporate health. With increasing labor costs, lower individual productivity, higher ratios of indirect to direct labor, higher breakeven points and higher taxes, much greater reliance will have to be placed on engineering if any profits are to be made and if free industry is to survive. Yet there appears to be a veil or curtain that separates the operations of industry

This article is abstracted from a paper presented by the author at the recent semiannual meeting of the American Society of Mechanical Engineers at Milwaukee, Wis.

and the university insofar as their training efforts are concerned.

Questionnaires, sent to representative midwestern industrialists, asked for pertinent information regarding policies and practices in developing technical personnel for greater responsibility. Except for a few commendable cases, the data indicate that the co-operation of industry with the university is but a feeble gesture. We walk our separate paths, and nod politely when they cross.

The results further indicate that close to half of the companies reporting have no plan for training the graduate after he is employed. Another third make a conscious but very informal effort to train and acclimate. Those that enlist university help or guidance are few.

This weakness is especially apparent in the smaller companies, some of which depend upon large companies for graduates of the more formalized training efforts, and some of which hire the graduates of universities directly and let them make their own adjustments and transitions. This seems particularly unfortunate because of the splendid opportunities that exist for individualized training and follow up of small groups. Perhaps it is expecting too much for a single company to create co-operative methods and programs suitable to this purpose.

Industry may look with disinterestedness on the university's or technical school's programs, but it cannot escape the fact that the ouput of these institutions constitutes the source of the most important ingredient going into their own products.

A Pause for Introspection

One could hardly conclude that co-operation between industry and the university is fully developed. Probably the fault should be laid at the door of industry. She is the customer and should give some expression to her needs. Moreover, part of the training of the engineer must take place within industry and it is here that the poorest job has been done.

Correlation of theory with practice is accelerated under guidance of instructor

The indicators of good health in engineering educational programs must be obtained from an evaluation of the preparedness of the trainee graduate. We must ask ourselves in utter frankness whether we are jointly doing the kind of a job that society, the taxpayer, the stockholder, the student and the customer have a right to expect. Does the school meet the requirements of industry and does industry adequately train and foster?

As a minimum the graduate should be expected to function as an engineer in some subordinate capacity, after a reasonable training period. This calls for more than a knowledge of technological procedures. The engineer interprets needs and then responds with ideas, sketches, blueprints, materials. Correlation of individuals, as well as of ideas and matter, are involved all along the line. He must know how to work in concert with others and how to communicate ideas to them. It is obvious that there is a sociological as well as a technological areas of development.

Objectives Must Be Restated

The entire field of engineering education-training ought to be re-explored. A broad gage national committee consisting of representatives of industry and university, provided with adequate funds to finance full time research and study would constitute an instrument for realistically coming to grips with the problem. Such a group could be expected to create plans for improved relations between school and industry together with recommendations for accomplishing objectives that would include:

1. Training of engineers for greater power, imagination, resourcefulness, and courage
2. Providing a more practical training. Making men who can *do* things
3. Instilling cultural tastes and habits together with an objective philosophy of life, a social consciousness, and a sense of industrial togetherness. Developing men with spiritual insights, and mature loyalties
4. Reducing the time (4 years of college and a minimum of 5 years in industry) required to produce an engineer capable of assuming responsible charge of engineering projects.

Technical and Practical Preparation

Much of the activity carried on in the engineering colleges should be relegated to the preparatory schools. The only reason for teaching rudimentary drafting at that point is to suit the needs of a small percentage who hadn't made up their minds before graduation that they might like to take engineering. All of the instruction in elementary machine shops, pattern shop, foundry and weld shop could be obtained prior to university matriculation. The student would then have obtained his "tools" at an age when he can develop dexterity as readily or even better than later. Eventually university engineering courses should be developed for students who are graduates of our technical and industrial high schools or have an equivalent preparation.

Walter P. Schmitter is active in the development of an extensive technical training program for Falk supervisors and graduate engineering trainees. This program includes weekly lecture sessions on all phases of company operations and monthly all-day clinics for selected supervisory personnel. A past president of AGMA, Mr. Schmitter will be remembered by readers for his extensive writing in the field of gearing and for his well-known formula for determining the capacity of helical and herringbone gearing

Some years ago a young man who had just completed his second year of academic high school consulted the author about transferring to technical high school even though it was certain that he would go on to the university. Being himself a graduate of such an institution he urged the student to try it. During the summer following his third year at Purdue the youth laid out a series of units that involved design techniques not ordinarily attained earlier than two years after graduation. This would indicate some startling possibilities .

Such preparation makes possible more advanced and more practical instruction at college. For instance, outside engineering service is engaged by many companies to handle the overflow of their drafting departments, usually detailing and simple layout. As often as not the organizations are in different cities. Technical colleges could participate in work of this kind, with the result that the youth would feel he was doing something "for keeps" instead of practice; there would be earlier orientation and a source of income for the school. The same holds true of certain shop work. Much of industry's testing could be carried on in the school laboratories; tests on new products, determination of operating characteristics and safety factors would bring the student into contact with the most modern industrial units in place of the too frequently archaic ones. Again there would be income and that psychological value, the satisfaction that comes from practical service. Do we not all labor, not for love of work but of accomplishment?

Earlier technical activity in the preparatory stages would be of considerable benefit to the student who drops out of school before graduation, as well as the one who should never have registered at an engineering school but does not find out until it is too late. There is an instinctive and intuitive element essential to the profession that can be fostered and developed but not taught. Those not blessed with it must do the noncreative jobs.

We all know that many engineering graduates spend their lives in jobs which could be filled with contented men of high school education or less. We know, too, that many of the university graduates gravitate toward jobs which in the strict sense of the word are not engineering but for which an acquaintance with its methods is useful.

When electives or majors leading to specialization are involved, aptitude testing should be employed to make sure that decisions are properly made. This also applies to graduate study. Whether any such study should be permitted without a year or more in industry should be carefully considered.

Observations of many engineering supervisors lead them to the conclusion that far too much of the college effort is devoted to application, specialization and nonessentials and that there is insufficient grounding in fundamentals, principles and methods. While it is true that almost any course of study develops the mind, it seems more practical to do it with useful materials of instruction. The small percentage of engineering graduates who will employ any given specialized course to an appreciable extent suggests confining the elements of such instruction to one of the basic courses. Because of the difficulty of keeping abreast of technological developments in industry, a student entering a specialized field has to relearn much of what he has covered in that field. Mechanics, mechanism, statics, and dynamics on the other hand are drawn on in almost any engineering field of endeavor and their truths are eternal. Possibly a year could be saved and yet the knowledge of fundamentals intensified.

Creative Faculties Should Be Nurtured

We think of the scientific method as the collection of all pertinent facts, both wanted and unwanted, their arrangement into systematic categories from which may be drawn intelligent conclusions. The observer in science coldly records without interjecting his personality into the situation. He lets nature do all the talking. The process in itself is not creative. Differing from the inductive scientific method, a new

Advanced theoretical instruction in specialized fields in a Falk class room supplement college education

concept, a new synthesis or an invention involves a leap of the imagination beyond the point where science stops. Too great a respect for the prevailing notions as to what cannot be done may inhibit the creative instinct. This arises first of all from a dulling of the imagination, a taming of the spirit, which in an untutored Edison runs strong and wild and free. Secondly, it develops from the fact that the false logic which indicates the impossibility of accomplishment frequently neglects an important factor or contains one of a variable nature.

There can be little doubt that much of the instruction can be reorganized to develop original thinking. Admittedly it takes more time. We can teach Euclidean geometry by supplying the student with only the axioms, assigning theorem one and having him find the solution without reference to a text; then

Practical knowledge is gained from experienced mechanics

with his axioms and theorem one, solving theorem two, etc., etc. Or we can teach it the conventional way in which he need only follow prescribed patterns. A similar approach is possible in mechanics, physics and other subjects.

Thought should be given to the use of certain classics for test, such as Newton's *Principles of Philosophy,* or Faraday's *The Forces of Matter,* which permit retracing original thinking and repeating the original experiments. The undergraduate as well as the industrial training effort should abound in projects calculated to bring out the latent creative talents and develop the artistic nature of the embryo engineer.

University Can Participate

An enlightened self interest would suggest realistic company attitudes toward engineering training responsibilities. The chief engineer should feel just as much concerned about developing engineers for future operations as about developing products for future sales; and the boss has a perfect right to evaluate him on that basis. Much of the mechanics of training is turned over to the personnel department but that does not relieve the engineering department of its share of the responsibility.

The Falk Corp. has for many years exhibited a genuine interest in employee development, and its pioneering work in the field of apprenticeship is well known. One of the heads of its personnel and training departments went to a large university as dean of engineering but has recently been guiding a program of advanced training at the corporation. Certain of the techniques employed show particular promise even though it is too early to report in detail. Suffice it to say that the university can be of great assistance in training beyond graduation, versed as she is in the art of communicating ideas and arranging programs. Industry will find the help of professional instructors essential to the development of a well rounded training course.

School and Industry Must Get Acquainted

European technical education has long contended that instruction should come largely from men who have attained recognition because of their industrial experience and achievement. The claim is made that more practical graduates are obtained. Many of the "technikums" require one or more years' experience in shops before matriculating students. There is not too much reason to borrow from abroad but certain subjects suggest a high degree of co-ordination with practice. Should these areas be developed, many industrial problems could be referred to the university.

Manufacturing concerns employ management and production counsel during times when revisions of departmental operations are under consideration. These consultants could very well operate from the technical schools and might even be part time faculty. Thus a common reservoir of modern methods and procedures would be tied into the school. Students specializing in this field could be used in the detail work of collecting data and installing new systems.

Greater recognition of the fact that many engineering graduates move into supervisory manufacturing positions must be reflected in the curricula. Tooling and processing are of rather general interest and helpful to the embryo designer as well as to the production expert of tomorrow.

Certain manufacturing associations having heavy technical programs invite professors to participate in their activities under academic membership. This brings to the school a better understanding of the problems of industry together with a more practical approach than in otherwise possible. This has demonstrated its usefulness and should therefore be extended.

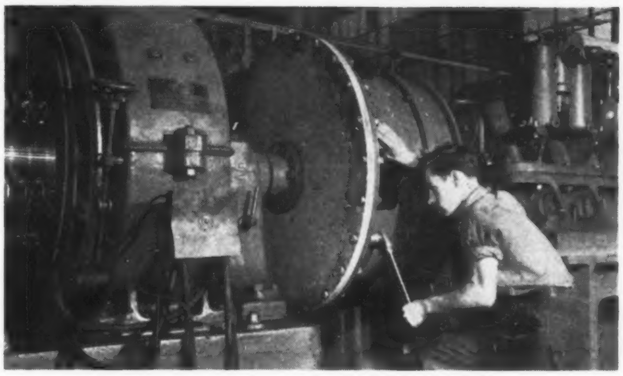
Leadership Can Be Cultivated

An industrialist who built up a good sized industry helped his children plan their university curricula so that they would have "that to live by, that to live

with and that to live for." The engineer should have a particularly broad base for his education since his vocation is of a confining character. There is room for considerable difference of opinion as to the degree of cultural emphasis practical in the education and postgraduate training of the engineer. A background that recognizes the streams of culture that constitute the basis of 20th Century civilization can serve as a stimulating beginning of the full life. The school can inculcate principles, ground a philosophy of life, develop attitudes, create thirsts and instill a sense of values which will provide a cultural beachhead for future excursions into the aesthetic.

One of the justifiable complaints about university graduates is that of immaturity. It is barely possible that the relationship between professor and student tends toward deflation of the youth at an age when he should be asserting the positive attributes of personality. Students should be encouraged early to participate in civic enterprises and enlist in the work of social agencies. This should be paralleled with lectures by individuals likely to stimulate proper interests. A good citizen, a "whole man", and a resourceful engineer need not be strangers to each other.

When industry receives the graduate it must be with warmth and understanding. He is making a readjustment of no mean proportions and he is doing this just as he reaches maturity, a time when the urge to hold his head high and throw back his shoulders is greatest. The trainee should not be denied any legitimate opportunity for development. The author is finding that these men can be used directly on preliminary design where the ideas are not yet sufficiently organized to release them from his own personal supervision. Some of these fellows exhibit a delightful enthusiasm and freshness and are unencumbered by too intimate a knowledge of existing constructions. Once they have absorbed sufficient background they must be permitted to go on to operations that call for independent action and early responsibilities. If we put the right kind of challenge up to them they will come through with a proper response. These are the seed brains for tomorrow.



The industrial test laboratory projects the trainee into the competitive commercial arena

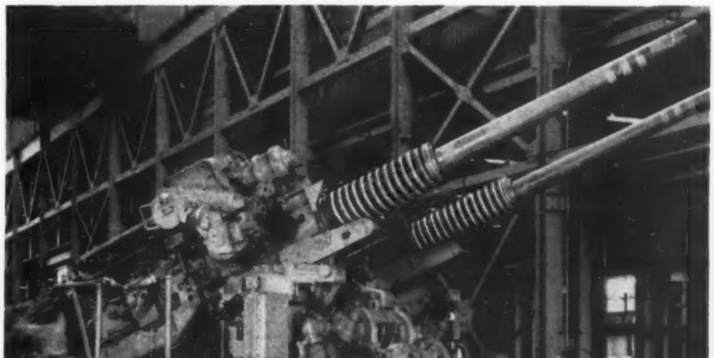
The engineering trainee must learn to work unselfishly and co-operatively toward the attainment of the overall objectives of industry, have faith in his company and its leadership and exhibit a quiet and dignified devotion to the free competitive way of life. Leadership is attained only when one gives himself to something outside himself. Paradoxically, this secures the primacy of the individual and the dignity of the person.

When the contemporary poet Robert Frost penned the line, "Men work together whether they work together or apart", he stated a truth applicable to all human participation; but it is certain that it has an especial significance for industrial society and particularly so in the field of university-industry relations in the development of engineers.

Six Times More Fire Power

Navy's new three-inch 50-caliber rapid-fire twin-gun mount will be installed on the major combatant ships of the Fleet. A great improvement over manually operated single three-inch guns, it will fire the famed VT or proximity fuzed ammunition and will provide effective close-in defense against high-speed aircraft and missiles. Automatic loading feature represents an important advance in gun design and makes possible from four to six times more fire power than older guns.

Result of the combined efforts of the United Shoe Machinery Corp., General Electric Co., the Naval Gun Factory, and the Bureau of Ordnance, the gun had its inception when the Bureau of Ordnance was given the task of devising a defense against the Japanese Kamikaze planes which constituted a major threat following the Leyte landings.



Aluminum Furnace Brazing

By P. A. Koerner
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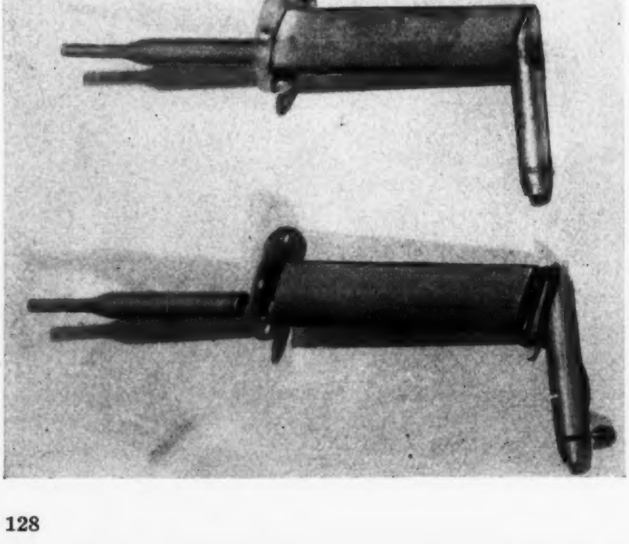
As A MEANS of fabricating aluminum assemblies, furnace brazing has several advantages. It is rapid, inexpensive and produces a strong, uniform joint. For these reasons, the parts illustrated, an aircraft pitot tube and a carburator air scoop, were redesigned for assembly by this method. Formerly, the parts were joined by a conventional manual process. However, using this older method, considerable skill was required, great variations in joint structure resulted and the base metal was often weakened.

The pitot tube, shown at the left before and after brazing, is made up of six components, the major three being 61S aluminum tubing. The O-shaped part at the elbow of the assembly is brazing alloy strip which melts in the furnace and forms the joint between the two adjacent parts. The two remaining flat components are made of brazing sheet consisting of 61S aluminum with brazing alloy clad on each side. Supported in an aligning jig, the assembly is placed in a forced-air furnace for several minutes and then air cooled. The parts are thus fastened together into an assembly having clean, smooth joints.

Somewhat more interesting is the air scoop shown at the right. This unit also consists of six parts. However, in contrast to the pitot tube, which requires a supporting fixture to align the parts while in the furnace, the scoop is self sustaining, requiring only a cradle to hold the parts and align a small drain tube. In this case, the major elements are stamped of brazing sheet clad on one side only. The small tubular elements are 61S tubing.

The simplified procedure used in the brazing of this part was largely made possible by a pre-assembly technique applicable to many types of sheet-metal brazing problems. As may be observed in the illustration, three projections or nibs are provided on the rearmost stamping. After the mating part is placed in position and located by means of the small winglike tubular elements at the top of the scoop, the projections are bent over and hold this much of the assembly in alignment. To complete the assembly, the annular flanged stamping is then lightly pressed into place. It is self sustaining in the furnace.

The aluminum furnace brazing process has four features which particularly recommend it to designers of aluminum parts. First, appearance and, if the part is properly designed, strength are superior to other methods of joining. This is evidenced by the uniform flow of the brazing metal as a result of the capillary attraction. Second, no highly skilled labor is required; the temperature and time cycles can be specified on the assembly drawing and the furnace controls adjusted to suit. Thus, the human factor is reduced to the minimum. Third, joining time per unit is reduced, sometimes as much as ninety per cent, since all joints are completed simultaneously. Fourth, if a component or part of an assembly is damaged or rendered unfit, it can readily be replaced, saving the balance of the assembly.



PRODUCTION PROCESSES...

Their Influence On Design

By Roger W. Bolz
Associate Editor, Machine Design

Part XXXVII—Cold Drawing

OFFERING possibilities similar to those of the extrusion process, cold drawing broadens the range of application to include ferrous metals. The use of cold-drawn and cold-finished rounds, hexagons, squares, etc., in both ferrous and nonferrous materials is well-known and requires no comment. The use of shapes in the design of machine elements to reduce machining cost or simplify production, however, demands careful consideration and

continued attention.

Although ferrous materials can be extruded hot within an extremely limited range, continuous shaped bars cannot be so produced at present. The process of cold drawing fills this gap in the field of shaped bars. While the variety of cross-sectional shapes that can be readily produced is considerably more restricted than with extrusion, the possibilities are nevertheless sufficiently broad, *Fig.* 1, to offer economical advantages. By designing with the limitations of the process in mind the economic advantages can be multiplied manyfold.

Any machine part which has an irregular cross section whose surfaces are parallel along all or a major portion of one axis are naturals to consider for production from multiple-length bars, *Fig.* 2. This is especially true where the amount of material necessary to remove in producing such a cross section comprises the greatest portion of the required machining. Assuming that the requirements of the design can be satisfied by a cold-drawn material and by its physical properties, the primary controlling factors which remain are the physical limitations of the process and the production quantities. In the final analysis, adapting a part to the cold drawing process often results in improved appearance, simplified design, increased strength, and longer wearing qualities.

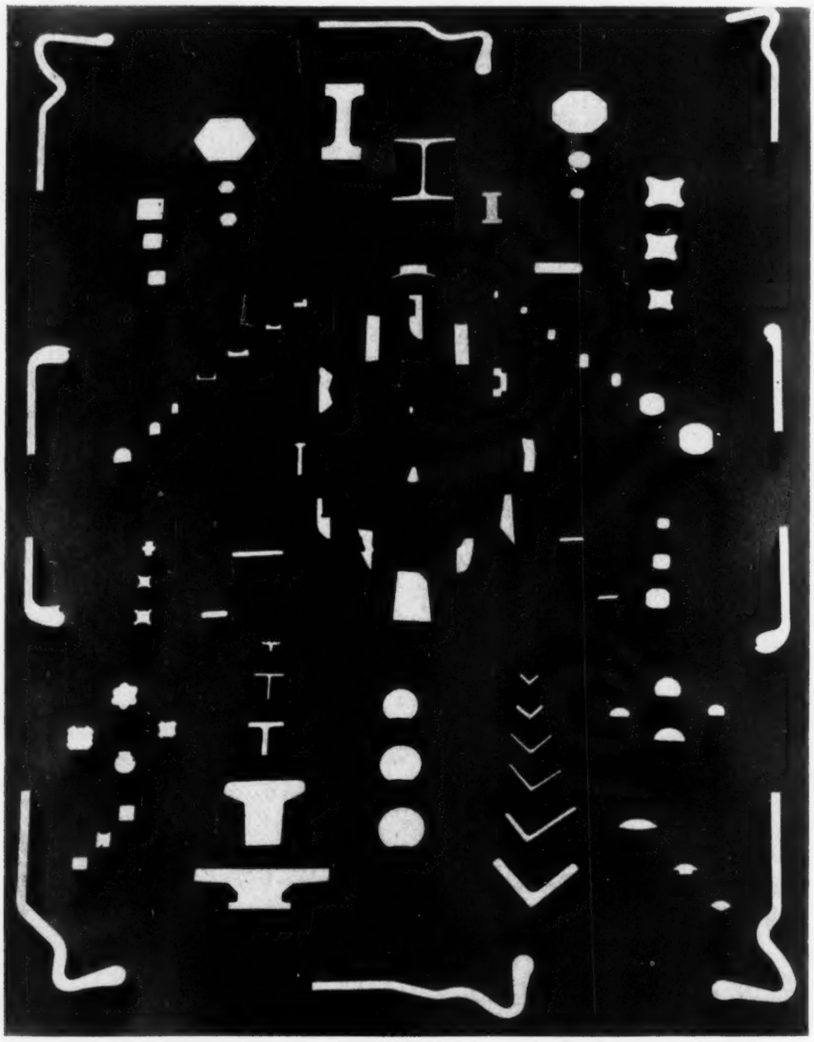


Fig. 1—Above—A variety of typical cold-drawn steel cross sections

Cold-drawn bars are normally produced from hot-rolled bars or coils prepared specially for the purpose. The hot-rolled material must be of top quality inasmuch as the cold drawing operation involves the elongating or stretching of the material which would accentuate any surface irregularities or defects. As a rule, the order of operations is as follows: (1) Pickling; (2) washing with water and immersing in lime solution; (3) pointing; (4) cold-drawing; (5) straightening; (6) cutting to length; (7) inspecting; and (8) shipping. Pickling is required to assure an unmarred cold-drawn finish.

Lime is Lubricant

Liming after washing assures complete removal of pickling acid and also serves as added die lubricant in drawing. Where bars cannot be started through the die by means of the regular pointing head, the lead end of the bars are reduced for a length of 6 or 8 inches by means of rotary swaging or, with intricate sections, by overpickling in acid.

The actual drawing operation comprises the pulling or drawing of the

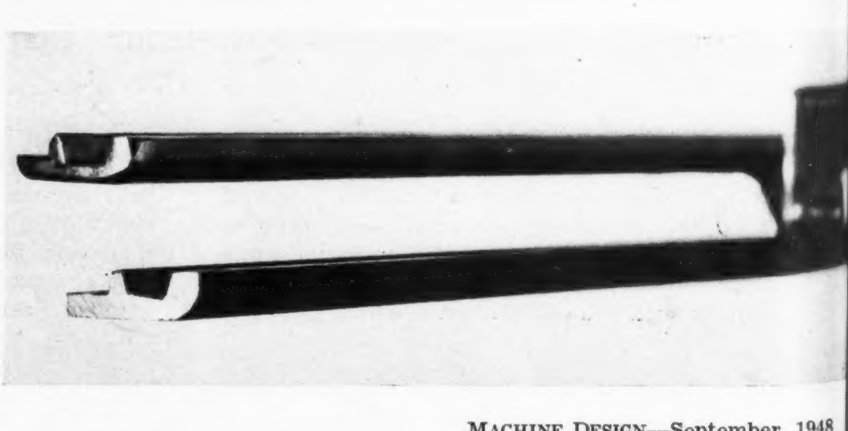


Fig. 2—Right—Finished carriage ball race for accounting machine and cold-drawn shape used

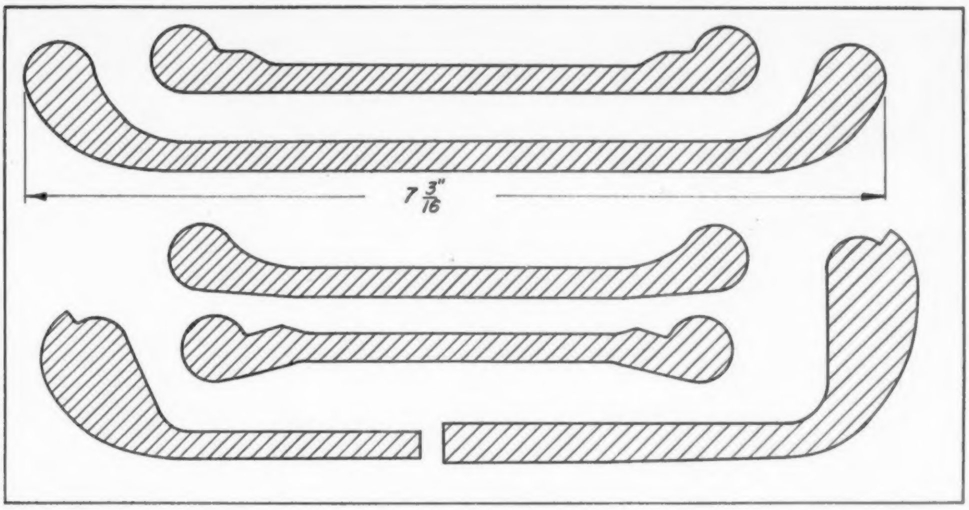
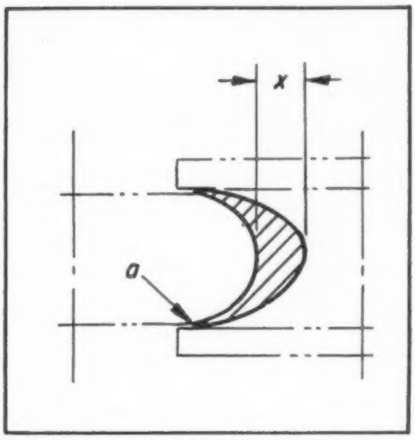


Fig. 3—Left—Six hot rolling passes and five cold drawing passes are used to produce this special section from a standard round

Fig. 4—Above—Special sections, hot rolled and given one cold draw to size. Wherever possible such sections should be designed to allow symmetrical rolling. Such sections can be parted after drawing to obtain two identical halves and simplify the drawing process

Fig. 5—Right—Turbine blade section of stainless steel. In order to hold dimension (x) to required tolerances and eliminate wrinkling or tearing of the extremely thin edge at (a) special roller drawing dies are required. Excess material drawn out at (a) is sheared to height in an extra operation



pickled and limed hot-rolled bar through the die opening. Machines used in drawing are the well-known draw benches. These draw benches vary in size and power and may be of any convenient length; usually from 30 to 75 feet. The mechanism consists of three parts; namely, the drive, the pointing head, and the pulling head. Once fed through the die, the bar is gripped by the pulling head and the pulling-head carrier is hooked to an endless block chain which is driven by a variable-speed motor through gears to draw the material through the die.

Special shapes are processed in a variety of stages. Multiple-pass cold drawing with intermediate annealings, is carried out using standard rounds, hexagons, squares, or flats as starters, *Fig.* 3. As a rule it is preferable for economical reasons to use up to three cold draws only, inasmuch as too many draws may overwork the material. However, as many as eight to ten passes are required for some sections to produce the desired profile, *Fig.* 3 being a good example. Size of sections handled normally ranges from approximately 0.030-square inch weighing about 0.1-pound per foot to a maximum of 6 to 7 square inches with weight per foot of 10 to 12 pounds. The maximum width of section runs to about 4 inches.

Another method comprises the cold drawing or finishing to size of sections hot-rolled to the necessary shape. Up to three hot rolling passes, and sometimes four, are used to produce the desired shape and the bar is then given one cold draw to size the section and improve surface finish. No actual shaping is done in the cold drawing operation; only a small uniform reduction is made. Only large parts are produced by this method; cross-sectional area and weight per foot being limited to about the same maximum as in multiple-pass work. Section width, however, can run up to 9 or 10 inches where required, *Fig.* 4.

Roller Dies Sometimes Used

A combination of the preceding two stages or methods can also be used or, where necessary, roller dies or Turks Heads may also be employed to reduce the frictional drag of solid dies. Parts such as turbine blades drawn from stainless are produced in such dies, *Fig.* 5.

Speed of drawing varies widely, depending upon the equipment, bar size and section, finish desired, material anlysis and physical properties, amount of

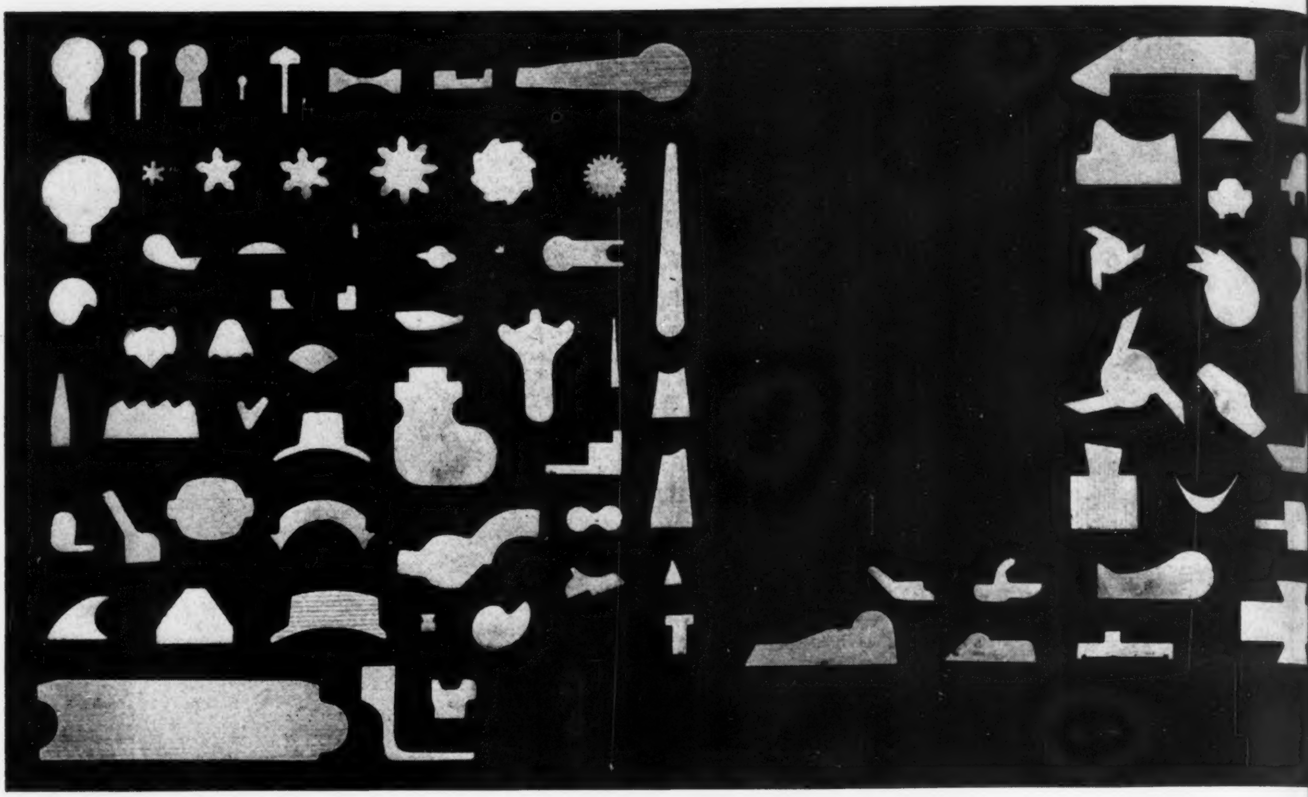


Fig. 6—Above—Group of typical drawn sections which portray the general range of section variation and types of tooth forms readily drawn in production

Fig. 7—Left—Special sections such as at (a) require hot rolling with a final forming draw to shape the thin extensions. Section at (b) is more economical and practical

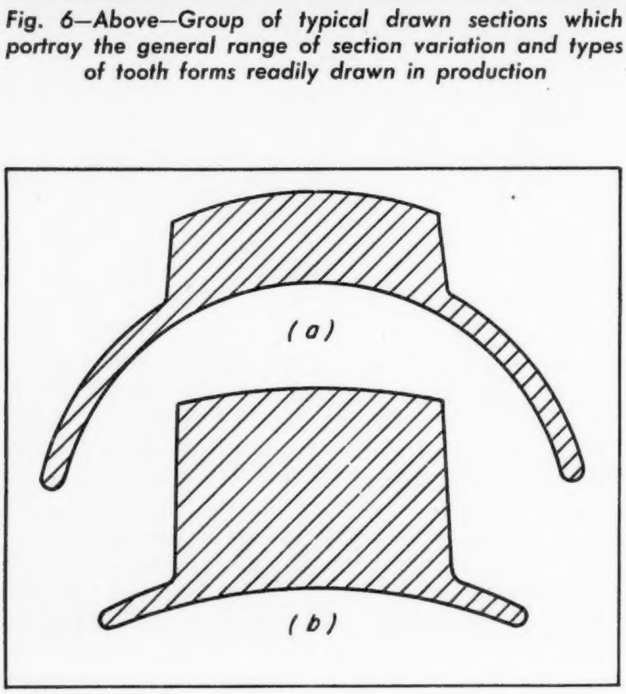
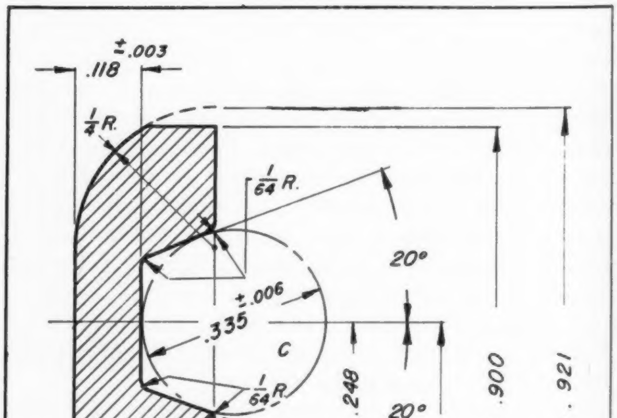


Fig. 8—Below—Typical section design used for the accounting machine carriage raceway shown in Fig. 2. The tolerances shown are typical of those normally held in mass production of shapes for machine parts



reduction, etc. The range of commercial drawing runs from about 40 to 100 feet per minute, although for sections such as flats, for instance, speed might be as low as 9 fpm while for shaped wire speed might be as high as 300 fpm. Generally, drawing speed for multiple-draw shapes ranges around 15 to 25 fpm while that for shapes, hot rolled and given one sizing draw, ranges around 50 to 60 fpm.

Production speeds such as these obviously require tonnage output to attain the greatest possible price advantage. A minimum quantity for small special

shapes might be placed at approximately 500 pounds; where quantity can be raised to about a ton or more on the initial order with similar quantities as frequent as once a year, die costs will be but a comparatively small part of the cost per piece. Where quantity ranges from 5 to 10 or more tons, special sections may cost even less than the simplest machining operations on a standard bar.

Shapes which are hot rolled and given one sizing draw require much greater initial output. Production should range around 100 to 150 tons per rolling for economy and where 3 or 4 rollings can be made per year, roll and die costs can be reduced to insignificance.

DESIGN: While it is preferable to begin the cold drawing operation with a hot-rolled shape closely approximating the desired cross-section, the process has been developed to a point where intricate sections can be drawn from unrelated hot-rolled rounds, square or flats. A small hot rolling mill is sometimes used to "break down" a standard section to one more suitable for cold drawing, *Fig.* 3. For maximum economy and prompt delivery, however, special shapes should be designed to approximate closely as possible an available mill hot-rolled section.

There are practical limitations to the shapes which may be produced economically. Metal in all parts of a section must have sufficient strength to withstand the drawing stresses. Reduction in area and cold working is thus limited; the usual reduction in area being about 10 to 15 per cent per stage. Actual dimensional reductions or "draft" used may range all the way from 1/64 to 1/8-inch on diameter.

Strength Limits Sections

Although the metal can be made to flow into extended sections of a die to a certain extent, the amount of such redistribution is limited by strength of the bar leaving the die. Light extended sections greater than 3 times their thickness in width are extremely difficult to draw, *Fig.* 6, although heavier ones have been produced up to around 6 times. Pinion rod for gears ranging from the very smallest to around 1-inch diameter in mild steel, 7/8-inch in high carbon, and 13/16-inch in stainless have been produced. Almost any tooth form including intermittent, spline and ratchet types can be supplied, *Fig.* 6.

Ordinarily, sections which are relatively wide in comparison with their thickness must be produced by hot or cold rolling, *Fig.* 7, although occasionally roller dies or Turks Heads can be employed to obtain the desired results.

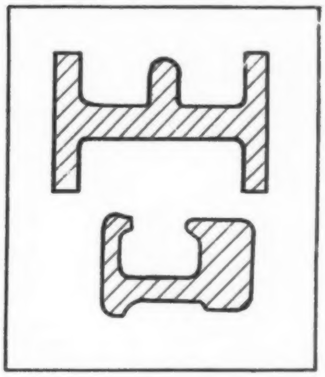
While shallow external undercuts, *Fig.* 8, can be produced where the depth does not exceed the width, complicated internal undercut sections are impractical. Many have been attempted but seldom are successful, *Fig.* 9. Where exacting undercuts are required such should be produced by machining, *Fig.* 10.

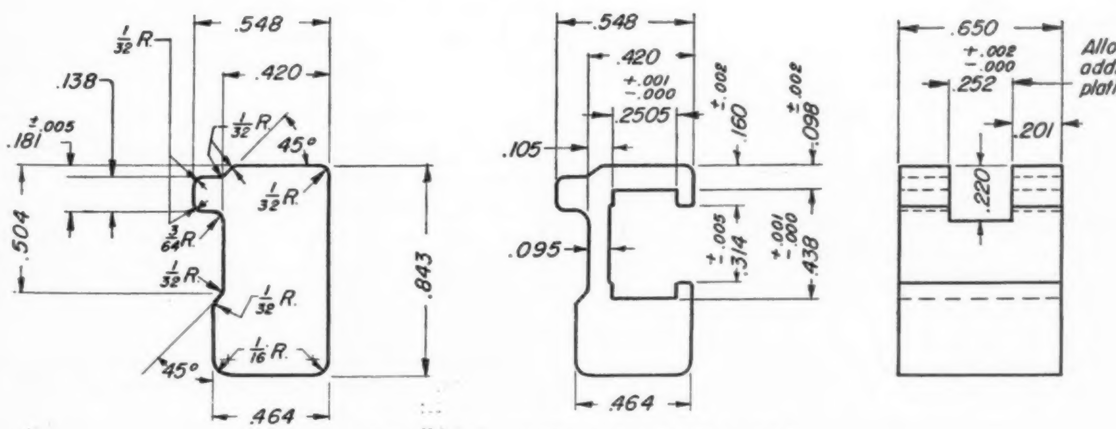
Extremely thin edges are undesirable. Edge extensions seldom can be drawn satisfactorily to uniform length and sharp edges. A radius is desirable and preferably a full rounded end of fair proportion in relation to the body section, *Fig.* 11, should be used.

Re-entrant or inside corners in some sections cannot be obtained readily with a radius less than 1/64-inch because of excessive die wear. Where sharper corners are needed, machining may be required, and in such cases a more generous radius will extend

Fig. 9—Right—Undercut sections which have been attempted in cold drawing but proved impractical

Fig. 10 — Below — Accounting machine carriage stop-body blank and drawn shape used in manufacture. Undercut portion is impractical to draw





Low carbon (0.05% to 0.15%) C.D.S.
Dimensions not otherwise specified may vary ±.003

die life considerably. In many designs an undercut can be used to achieve close fits between parts and allow desirable drawing radii where required, *Fig.* 12.

Generally, fillets should be specified with minimum radii of 1/64-inch on the smallest shapes with proportionally increasing radii as the size increases. External corners can, on the other hand, be sharp wherever desired.

MATERIALS: All grades of carbon, alloy or stainless steels that can be hot-rolled are obtainable in cold-drawn form. The softer steels—those low in carbon and hardening alloys—yield most readily to the cold drawing operation. Consequently, the soft open-hearth steels up to 0.50 carbon content are probably the most economical to draw, alloy steels follow, and stainless alloys are the most difficult to handle. Bessemer steels are of poor drawing quality and are undesirable for any shape requiring over one draw.

While a soft, ductile steel may be drawn to a comparatively simple cross section in two or three passes through progressive dies, a harder steel may require additional passes and possibly preliminary and intermediate anneals to produce the same section. Drawing cost increases and production speed decreases, therefore, as the workability or ductility of the material decreases.

Although machinability of most carbon and alloy

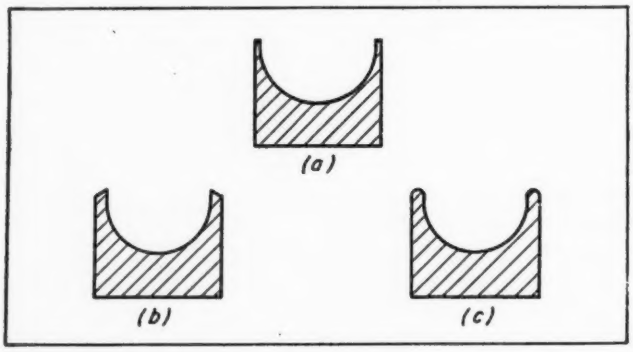


Fig. 11—Extension of section (a) may not be sufficiently strong for drawing. Section at (b) can be drawn but (c) eliminates the sharp corners and thin portions

steels is improved by cold drawing, where operations such as cutting off, drilling, tapping, or finish machining are involved, machinability is an important factor and should be kept in mind in selecting the most economical material.

Regular steels are considered as those up to 0.60 carbon content, those over 0.60 carbon being classified as tool steels. Shapes can be obtained in standard or special analysis oil or water hardening tool steels. Tool steels are especially advantageous on those machine parts requiring precise heat treatments.

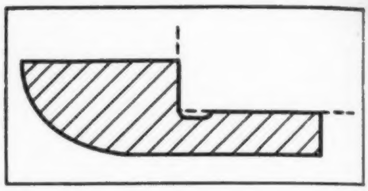
Being the most difficult to draw of the steels, stainless is restricted to use where shape can be very simple and symmetrical.

High surface wear resistance imparted to tooth forms which are cold drawn often obviates heat treatments. Smooth, hard uniform surface attained in cold drawing steels provides the optimum finish desirable on gears, ratchets, cog wheels, etc. Improvement in physical properties by cold working will often allow the use of a lower cost steel without sacrifice in strength.

TOLERANCES: In addition to increasing machinability and strength, the cold drawing operation also produces a smooth, bright surface of excellent appearance. Paints can be applied direct without special surface preparation.

Owing to the excellent surface produced by cold

Fig. 12—Where close fit is necessary, a corner relief will make possible the most desirable drawing radii



drawing, the necessity for machining can often be eliminated. Thus, wherever possible the surface as drawn should be used. In addition, the improved wear resistance imparted by the cold working is largely lost if the surface is machined away. Inasmuch as cold worked material has a tendency to distort if partially machined, parts so designed may require annealing to overcome this tendency and the additional cost of this operation should be kept in mind.

Dimensional tolerances possible by means of cold drawing are of considerable importance inasmuch as the accuracy will often obviate further machining. Whereas plus or minus 1/16-inch is normal in the production of hot-rolled forms or shapes, commercial tolerances for cold-drawn sections range around plus or minus 0.003-inch, *Fig.* 10. In the largest sections and in the interests of economical production, plus or minus 0.005-inch should be used if at all possible. Noncritical dimensions should be dimensioned with the widest possible tolerances to simplify the problem of holding the critical fits as close as possible, *Fig.* 8.

In the case of the smallest shapes which are relatively simple, critical dimensions can be held to plus or minus 0.001-inch and on occasion to a total variation of 0.001-inch. Gear, spline and ratchet tooth forms can be produced to acceptable commercial standards and often to better accuracy than with machining methods.

Length tolerances for various types of parts are, of course, dependent upon the method by which such portions are produced. Typical tolerances practical for such parts can be found by reference to previous articles of this series covering the process contemplated, turbine blades, for instance, being finished by means of automatic form milling as discussed in Part XXII.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

Jones & Laughlin Steel Corp. (*Fig.* 1) .. Pittsburgh, Pa.
National Cash Register Co. (*Figs.* 2, 7, and 9) Dayton, O.
Rathbone Corp. .... Palmer, Mass.
Republic Steel Corp. (*Figs.* 3, 4, 5, 6, 8, 10, 11, and 12) .... Cleveland, O.

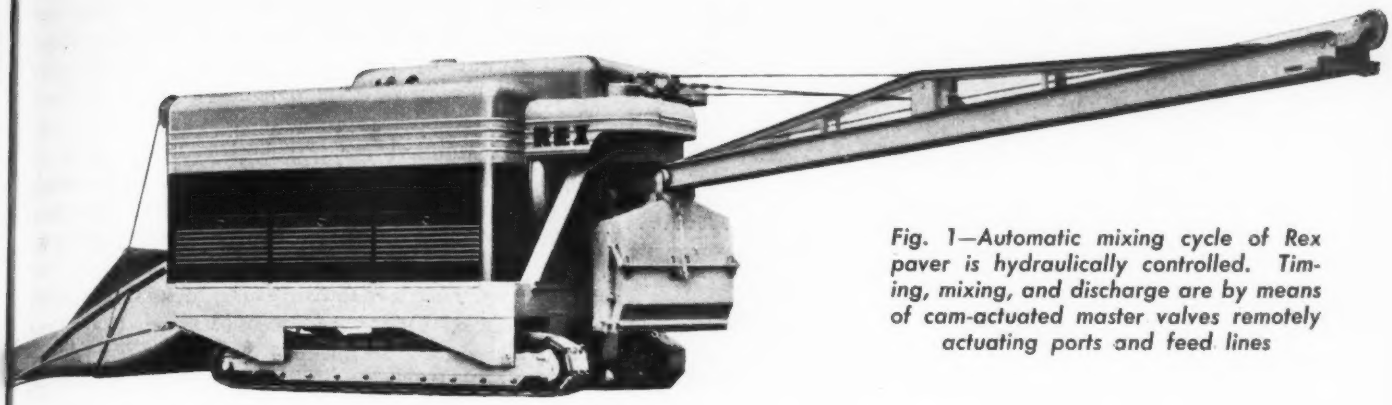


Fig. 1—Automatic mixing cycle of Rex paver is hydraulically controlled. Timing, mixing, and discharge are by means of cam-actuated master valves remotely actuating ports and feed lines

New Road Machines Feature Hydraulic Controls

American Road Builders' Show indicates continued trend in application of hydraulics

SMALL medium and large road building machines displayed at recent Road Show at Chicago's Soldier's Field, almost without exception were hydraulically actuated, particularly where control was difficult. Fluid power was used where high-speed reciprocating motion was required, where unusually long strokes were necessary and where precise rotation was desired. In several instances machines were entirely actuated or controlled by hydraulic systems.

Outstanding as an example of near-complete application of hydraulics is the Rex Paver, *Fig.* 1. This concrete mixing and laying machine receives cement and gravel at one end and spot-places the wet mix by means of a 35-ft rotatable boom. Operation of this machine is complex, for a single operator controls loading, mixing and placing of the concrete. To simplify the operation, the mixing and dumping cycle is automatic, using a cam-actuated hydraulic system. This automatic Hydrocycle control regulates the quantity of material admitted to the mixture as well as the mixing time, and deposits the finished material into the delivery bucket. Hydraulic cylinders take the place of mechanical levers in opening and closing ports.

Equally unusual is the Hydrocrane, a truck-mounted

Fig. 2—Front and rear-wheel steering of Motor Dozer is by hydraulic cylinders linked to wheel housings

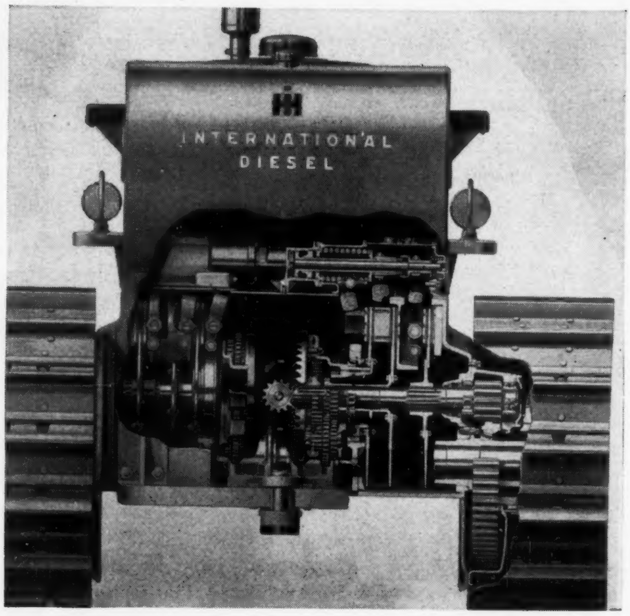


Fig. 3—Selective braking of planetary elements varies track speed for turning. Two sets of "pacing" or control planets are actuated by braking master sun gears. On common shafts with driving planets, the pacing pinions permit selection of high, low or zero speed

crane which is 100 per cent hydraulically operated. Power is produced through two 5000 psi pumps which are direct coupled to the truck prime mover. By means of a simple valving system at a central control panel, outriggers are extended and raised, the boom is telescoped and raised, and the platform is rotated. All of this is done by means of hydraulic cylinders. In addition, the load is hydraulically raised and the bucket opened and closed at the operator's will.

Similar in some respects is the Gradall, a highlight of the show previously described in MACHINE DESIGN. This machine attracted wide attention with its axially rotating and retracting boom. All motions of this unit too are hydraulically controlled.

Bulldozers have long used hydraulics to raise and lower their pushing blades. Now, with their increased size and weight, hydraulics is being used for steering. It is applied in two ways, depending upon whether the machines are wheel or track types. In the first instance, exemplified by the Motor Dozer, *Fig.* 2, hydraulic cylinders fixed to the four wheel housings pivot them around a ball joint. Particularly ingenious is the method used to achieve short-turning radii. For ordinary operation front-wheel steering is used, the rear-wheel steering mechanism being locked. When an unusually short turning radius is desired, the steering wheel is raised or lowered to feed power to the rear-wheel cylinders.

Track Speed Hydraulically Controlled

Steering method being used on full-track machines utilizes hydraulic control of the track drive elements. Variations of this technique are used on the Oliver, International and Allis-Chalmers units. Purpose in each instance is to eliminate the jerky steering so characteristic of crawler tractors. The old system was to brake the track on the opposite side of the machine from the direction of turn. New trend is to use a planetary system to produce variable-speed differential between the tracks, and thus two or more choices of turn radius. As shown in *Fig.* 3, heart of the system used on the International tractor is a planetary arrangement in which the output speed to each track may be changed by changing the relative speeds of ring and planet gears. This is achieved by means of two sets of "pacing" planet gears, action of which is controlled by hydraulically operated disk brakes. Three sets of brakes permit choice of high, low or zero output speed in either track. Turning radius is fixed proportionately.

Hydraulic transmission is used on the world's largest tractor, the HD-19, shown in *Fig.* 4. Use of the hydraulic torque converter in a tractor is particularly advantageous because the load can vary so widely and so rapidly. By its use, the speed of the tractor is matched against the load so as to deliver full power produced by the engine. Made possible by the cushioning effect of the transmission is a diesel operating speed of 1750 rpm, an unusually high speed for this service. This, in turn, makes possible a reduction in diameter of the torque converter, the result being a compact, light unit.

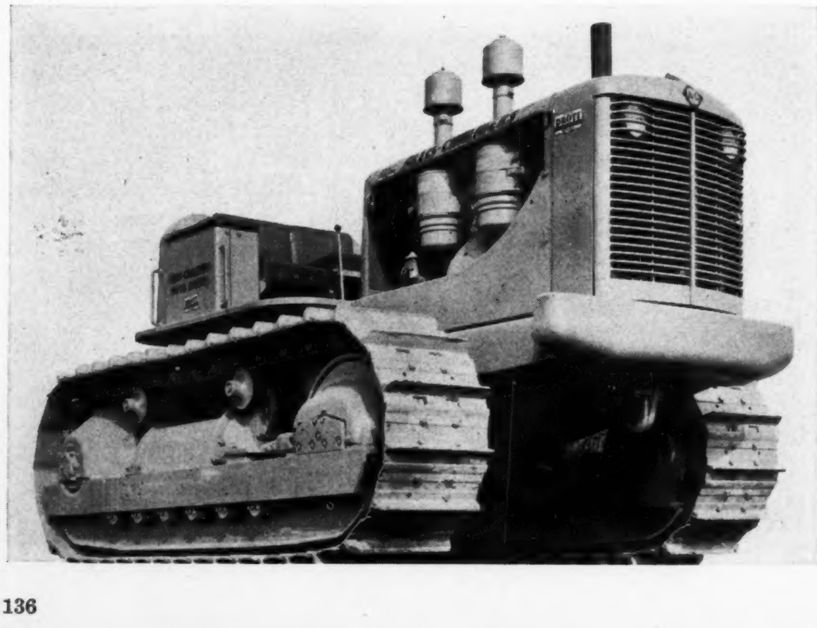
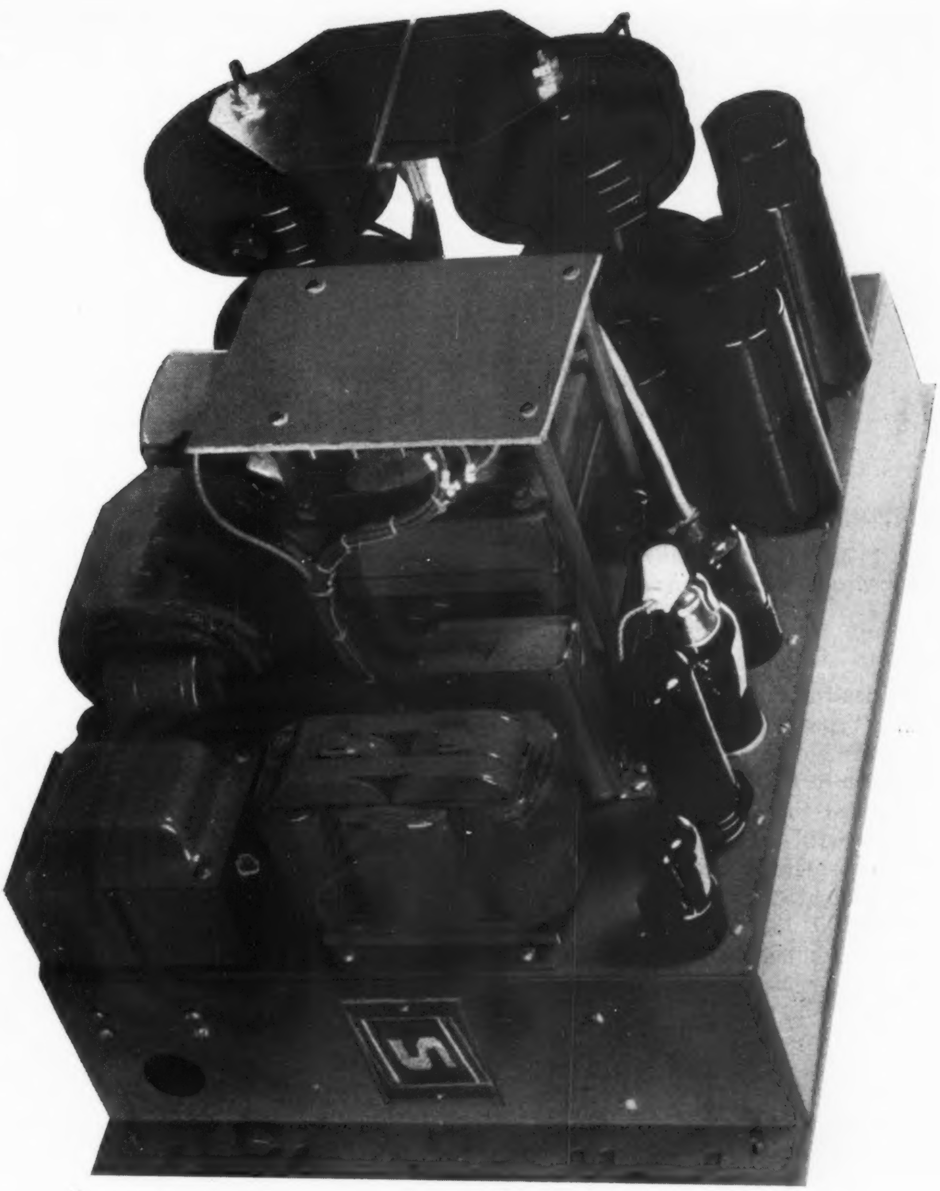


Fig. 4—World's largest crawler tractor, the HD-19 diesel, has torque-converter drive and high-speed engine

Motor Speed Control

. . . employs simple circuit with a compact saturable-core reactor



By Leo Helterline

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Sorensen & Co.
Stamford, Conn.

IN many electrical and mechanical devices there is a definite need for a different method of transferring relatively small amounts of electrical power into larger power levels by exercising some degree of control of the higher power circuits. The problem of controlling motor speeds for the feeds of various lathes and other complex machine operations has brought this need very much into the open.

A basic circuit element, the saturable-core reactor, may be employed for this purpose. This device, often known as the magnetic amplifier or electromagnetic transducer, operates on the basis that as a d-c field is set up in magnetic material, the permeability of this material decreases rapidly. Since the inductance of a reactor or choke coil depends on permeability, using this inductance of coils wound on a magnetic circuit as an a-c impedance and having a method of accurately varying the d-c flux flowing through this circuit makes a useful control element.

Shown in *Fig.* 1 is a common type of saturable-core reactor. The center leg is the d-c coil which, in this particular case, has a large number of turns of fine wire. The a-c coils are on the two outer legs and are connected in such a way that the a-c flux bucks through the center leg where the d-c coil is located. The flux is additive around the outer loop.

The accompanying table lists commercially available saturable-core reactors, giving their characteristics and useful ranges. This is an effort to standardize these control elements in the most useful ca-

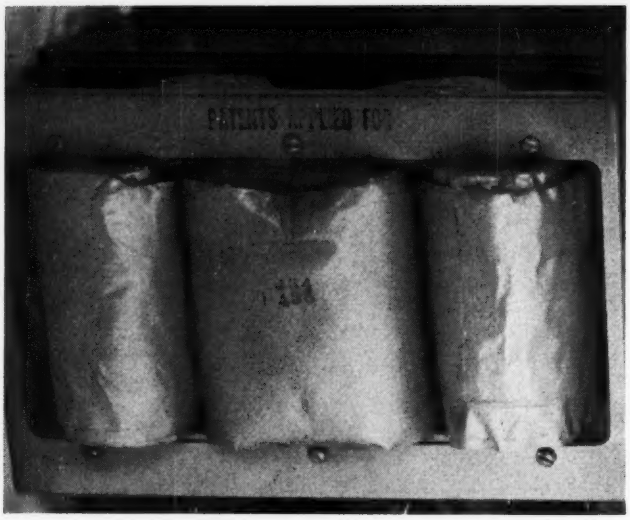


Fig. 1—Saturable-coil reactor is compact coil that can be hermetically sealed. The d-c coil is in center with a-c coils at each side

tegories for the control of a-c power. There are many other types of units which have been produced, but they are not quickly standardized.

Given in *Figs.* 2 and 3 are characteristic curves for a typical unit. It will be noted in comparing the curves with the data shown in the table that there is a considerable amount of range available which is not indicated in the tabulation. This is largely because it lists parameters which are most easily obtained in conventional circuits. However, by adapting proper methods of control, the d-c flow through the reactor may be obtained over the ranges shown in the curves and the full characteristic may be employed.

A saturable-core reactor has the following advantages when used for controlling power circuits:

1. It has no moving parts
2. The large heavy components may be located at a position remote from the control point
3. Unit is completely variable, requiring no tap changing or turn bridging
4. Unit may be hermetically sealed, enabling it to operate in corrosive atmospheres which would normally impair the operation of other equipment of this general type
5. Cost is low
6. It has relatively high efficiency.

Properties of Saturable-Core Reactors

Dimensions (LxWxH, inches)	Nominal A-C Impedance (Ohms)	Range of A-C Impedance (Ohms)
3½ x 4½ x 2¼	250	130 to 1400
4 x 5¼ x 2 5/8	130	60 to 700
4¼ x 6¾ x 3	60	30 to 330
4¾ x 6¼ x 4 5/8	30	15 to 170
11 3/8 x 7½ x 4¾	15	7 to 75
13 x 6¾ x 7¾	5	3 to 33
2¾ x 3¼ x 3*	400	200 to 2200
3 3/16 x 3 5/8 x 3*	60	30 to 330

* Suitable for 400 cps service. All other reactors shown are designed for 60-cycle, 115-volt service

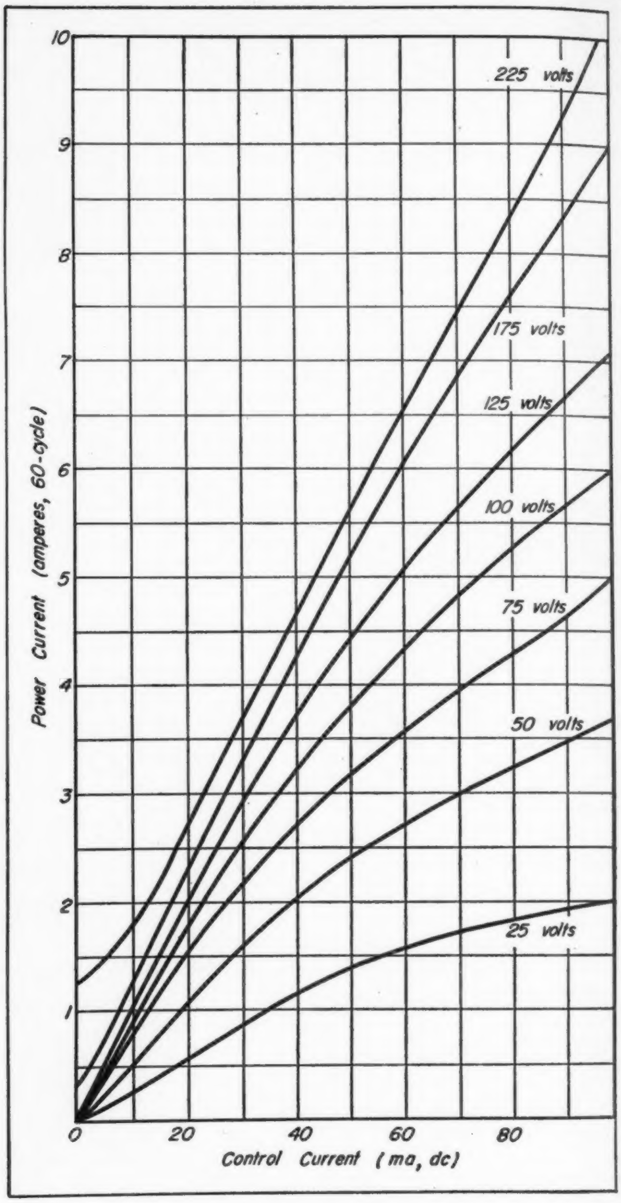


Fig. 2—Curve showing power output vs. saturation d-c current for typical saturable-core reactor

Disadvantages of the unit are:

1. Unit causes harmonic distortion (This may be filtered out rather easily, however)
2. Practical control range is generally over a 10 to 1 voltage or impedance range
3. Load regulation is relatively high.

Shown in *Fig.* 4 is a simple control arrangement using the saturable-core reactor. This will serve as an indication of the utility of such a device. The items identified on the drawings are as follows: *A* is a saturable-core reactor composed of a magnetic circuit denoted by the three parallel lines, the a-c coil on top and the d-c coil below. This is the schematic representation commonly employed in these types of units. *B* is a rectifier which rectifies a portion of the a-c input used in conjunction with the potentiometer *C* and the small condenser *D*. *E* is the load into which it is desired to vary voltage.

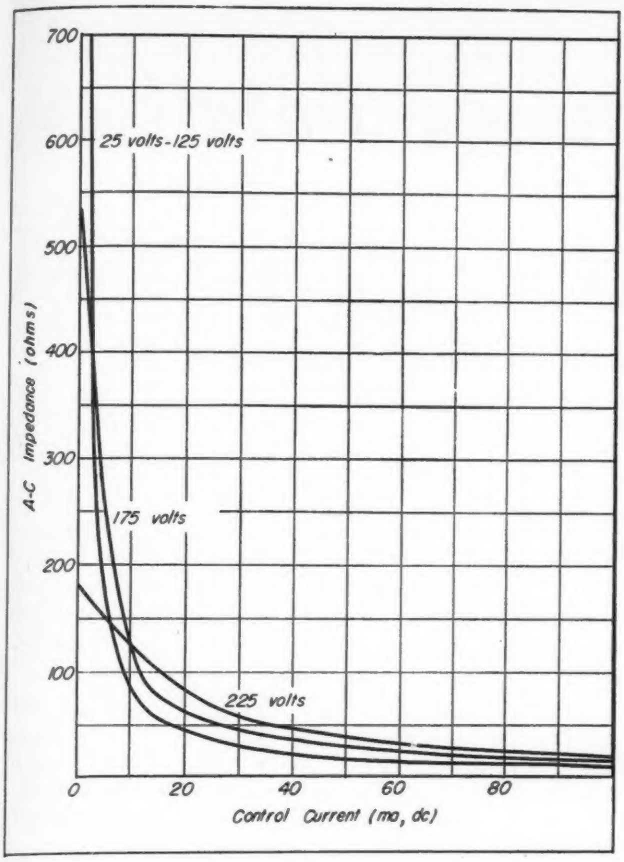


Fig. 3—Curve showing impedance of reactor as plotted against saturation d-c current

The amount of power required to actuate the d-c coil is approximately 1/100 of that which is available for the load. In most cases the ratio becomes as high as 1 to 500. This is a particularly valuable characteristic. Assuming, for example, that the load consisted of heavy elements, *C* could be a potentiometer located some distance from both the load and the reactor. Inasmuch as a very small fraction of the power flows through the elements *B*, *C*, and *D*, they are small and require little panel space. The capacitor, potentiometer and rectifier for a 500 va unit, would not occupy more than 100 cubic inches.

Simplicity of the components presents other advantages. The reactor, for example, may be used where chemicals, oil, grease or moisture are present without any harmful affects. A considerable advantage is the fact there are no moving parts except the control potentiometer. This may be located at a convenient protected point, or potentiometers may be used which are virtually proof against all types of atmospheric conditions.

There are many other possibilities of this type of unit which excite the imagination and which have been employed successfully. These include the possibility of automatically controlling the potentiometer. This may be done by a thermal-expansion linkage. The element *C* also may be actuated by pressure or may take the form of an electronic circuit. It may be used in conjunction with relays, or units may be cascaded, etc. Another straightforward application of the reactor is in conjunction with the many thyra-

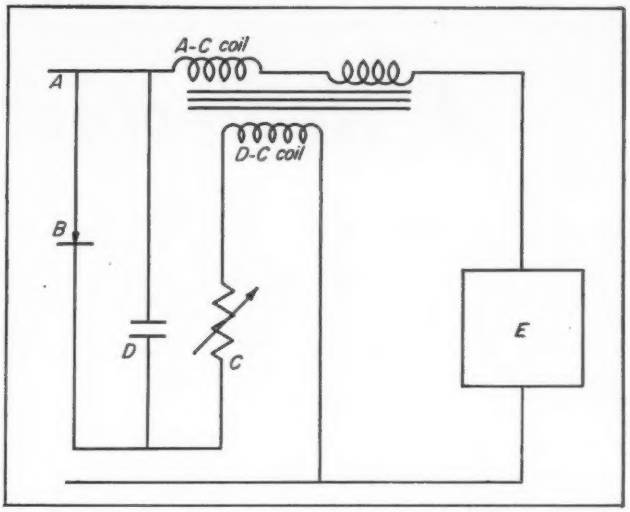


Fig. 4—Typical control arrangement employing saturable-coil reactor. Potentiometer, C, can be remotely located

tron circuits which are employed in newer designs. Used in this manner they provide a flexible method of grid phase shifting.

It is interesting to point out that the saturable-core reactor is not a new device by any means. It has been the object of much recent interest because other circuit elements have advanced to the stage where use may be made of them in conjunction with the reactor.

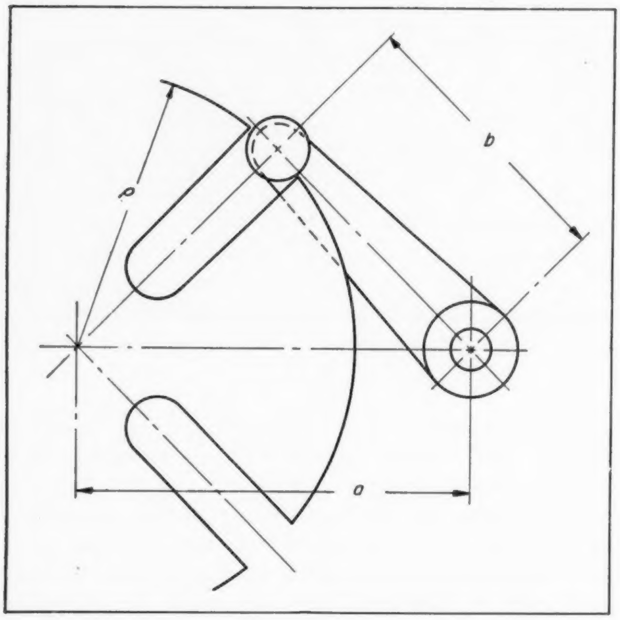
Analysis by Analogy

CALCULATOR designed by Westinghouse engineers to solve difficult problems in the fields of kinematics, applied mechanics, heat flow, and electrical circuits, does not operate by the rules of formal mathematics. Instead, it solves problems by using an electrical analogy of the forces being studied. Impacts, heat applications, pressures, etc., are represented by electric voltages or currents applied to a "synthetic machine" composed of electrical devices such as capacitors, resistors and inductance coils. Resulting voltages, representing stress, motions, temperatures and so on, can be measured at any point by connecting the leads of a cathode-ray oscilliscope to the analogous parts of the synthetic machine. A trace on the oscilliscope screen is an exact replica of the magnitude of the corresponding quantity in the actual machine.

Operation of the calculator is based on the fact that every mechanical element has its exact counterpart in electrical circuit elements. Thus, two meshed gears, one with high speed and low torque and the other with low speed and high torque, could be represented by a transformer with a high-voltage, low-current winding and a low-voltage, high-current winding.

A large device, the computor occupies seven cabinets, two of which provide voltages for simulating forces. Other cabinets provide means for varying the constants, and synchronous switches for repeatedly applying the synthetic force voltage.

A Neglected Design Detail



By Sigmund Rappaport

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WHEN designing an external geneva wheel the majority of designers neglect to take into account the effect of the roller diameter upon the proper functioning of this mechanism. The method generally employed for calculating the outside diameter of the geneva wheel is as follows:

Having chosen the center distance a, *Fig.* 1, the length of the crank arm b is calculated. For a four-slot geneva, $b = a/\sqrt{2}$; for a geneva wheel with n slots, $b = a \sin 180°/n$. Similarly, the outside diameter of the wheel, 2ρ, is taken to be $a\sqrt{2}$ for a 4-slot drive and $2\,a \cos 180°/n$ for n slots.

However, this would be correct only for zero roller diameter. *Fig.* 2 shows that if the foregoing method is used the roller does not come in full contact with the slot at the moment when the roller is supposed to start its driving action, that is, when the crank radius is at a right angle to the slot. The crank must rotate through a small additional angle before the roller touches the sides of the slot, which results in a shock, audible as a light knock.

Fig. 1 — Above — Essential proportions of geneva mechanism. The locking device is not shown in the sketch

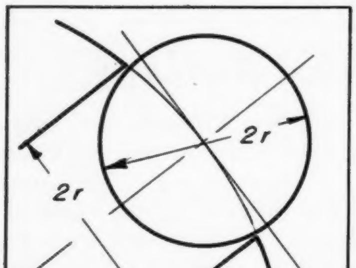


Fig. 2—Left—Detail of pin and entrance to slot, showing how roller fails to contact slot when it is supposed to start driving

Requirements for Smooth Operation

For smooth operation the condition is full engagement between roller and slot at the moment when arm and slot are at right angles. In order to achieve this, the corrected outside diameter $2R$ of the wheel, *Fig.* 3, has to be calculated from the equation

$$2R = 2\sqrt{\rho^2 + r^2} \qquad (1)$$

This formula gives, for a four-slot geneva, the value

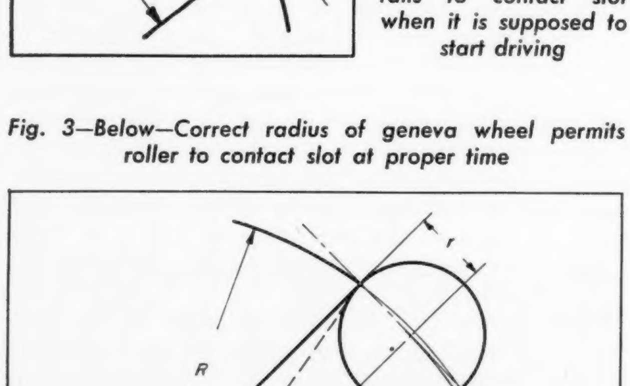
$$2R = 2\sqrt{\frac{a^2}{2} + r^2} \qquad (2)$$

and for a wheel with n slots:

$$2R = 2\sqrt{a^2 \cos^2 \frac{180°}{n} + r^2} \qquad (3)$$

The beneficial effect of this procedure makes itself felt especially if the roller diameter is comparatively large.

Fig. 3—Below—Correct radius of geneva wheel permits roller to contact slot at proper time



Modified Approach Permits Flexible Planetary Design

By Sergei G. Guins
Project Engineer
Office of Research Consultant
The Chesapeake & Ohio Railway Co.
Cleveland

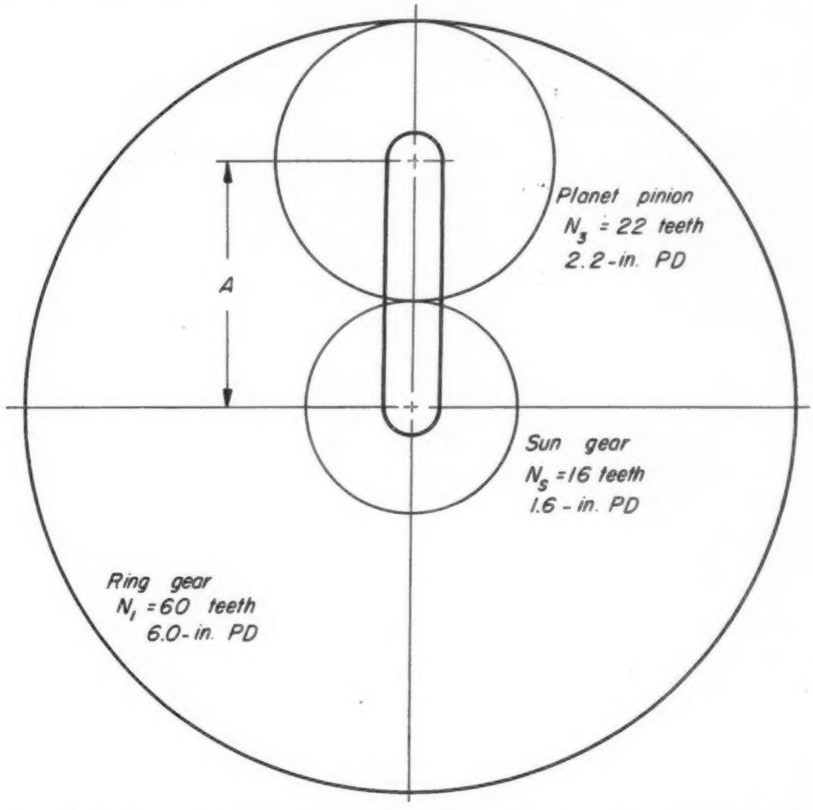


Fig. 1—Planetary drive for which three pinions were found to be inadequate but five could not be accommodated. Modification of standard design procedure permitted use of four pinions

IN his *Manual of Gear Design*, Section II, Buckingham presents a simple and straightforward method of calculating a simple planetary drive having sufficient strength and contact ratio. A good feature of the resulting drive is that interference between teeth is avoided, so that it is wise to follow Buckingham's plan for the design of most planetary drives.

There are cases, however, where this procedure cannot be followed, and another planetary must then be selected as an alternative. If this is done, attention must be paid to interference. Buckingham lists the different types of interference possible and provides methods of checking for them, but calculations prove to be quite long and tedious. This article discusses a method by which they can be avoided.

As an illustration of this the planetary shown in *Fig.* 1 will be considered. It consists of a standard sun gear, a standard pinion and a Buckingham ring gear. This system is advantageous not only in the light of no interference, but also because of the fact that it allows for the use of an even number of pinions where a Buckingham planetary (for pinions of 16 or more teeth) requires an odd number of pinions.

There are several reasons why an even number of pinions might be required in a planetary. For example, three planet pinions could be used in *Fig.* 1, but the dynamic load on the gear teeth in this application would be extremely high, thus requiring a large face width. Five planet pinions could not be accommodated. The following proof shows why a planetary consisting of a standard pinion, a standard sun gear and a Buckingham internal gear makes possible the use of four pinions where a Buckingham planetary does not. The legend for the symbols included in the explanation is as follows: N_1 = number of teeth in the ring gear; N_s = number of teeth in the sun gear; N_3 = number of teeth in the planet pinion; n = number of planet pinions; P = diametral pitch; and A = center distance = $(N_1 - N_3)/2P$.

Why the Buckingham planetary does not allow for the use of four pinions will first be explained. For such a planetary, the number of teeth in the sun gear will be*

$$N_s = 2AP - (N_3 + 1) \qquad (1)$$

In order that the special pinion will mesh with the

* Buckingham, *Manual of Gear Design*, Section II, Page 131.

TABLE I

Standard and Buckingham Pinions Compared

			Standard Pinion*	Buckingham* internal drive pinion
No. of Teeth			22	22
Diametral pitch		P	10	10
Pitch Radius		R	1.100	1.100
Outside Radius		R_o	1.200	1.225
Root Radius (hobbed)		R_r	0.9843	1.0093
Addendum	=	R_o-R	0.1000	0.1250
Dedendum	=	R-R_r	0.1157	0.0907

* See Buckingham, *Manual of Gear Design*, Section II, pages 93 and 109.

sun gear one tooth is subtracted from the sun gear. This provides stronger teeth and a better contact ratio. The explanation lies in the fact that the Buckingham pinion is a special gear with a longer addendum than that of a standard pinion as shown by TABLE I. Although the addendum of the Buckingham pinion is greater and the dedendum less, the tooth height is the same in both cases.

Substituting the value for A, the center distance, in Equation 1:

$$N_s = 2\,\frac{N_1 - N_3}{2P}\,P - (N_3 + 1) = N_1 - 2N_3 - 1 \quad (2)$$

A condition that must be satisfied before all the pinions will mesh both the ring gear and the sun gear is that

$$\frac{N_1 + N_s}{n} = \text{a whole number} \quad (3)$$

If Equation 2 is incorporated in Equation 3, the following condition results:

$$\frac{N_1 + N_1 - 2N_3 - 1}{n} = \frac{2\,(N_1 - N_3) - 1}{-n} = \text{a whole number} \quad (4)$$

In Equation 4, $2(N_1 - N_3)$ necessarily is an even number and when one is subtracted from it there will be an odd number in the numerator. Since, if the denominator were an even number the result would be a fraction; the denominator must be an odd number.

With a standard pinion instead of a Buckingham pinion, four pinions could be used because the following equation would replace Equation 4:

$$\frac{2\,(N_1 - N_3)}{n} = \text{a whole number} \quad (5)$$

In this case the one tooth is not subtracted from the number of teeth in the sun gear because a standard pinion and a standard sun gear are in mesh. It is easily seen that n *could* be four if $N_1 - N_3$ were an even number.

After selecting a standard sun gear, a standard pinion and a Buckingham ring gear, the interference must be checked. There is no interference present when a pure Buckingham planetary is used. A careful study of the matter proves that there will be even less with the given planetary. TABLE I and *Fig.* 2 serve to substantiate this statement.

Points of possible interference are at A and B in *Fig.* 2. At A there must be sufficient clearance between the root radius of the pinion and the internal radius of the ring gear. At B it must be between the root radius of the ring gear and the outside radius of the pinion.

Outside radius of the standard pinion is 0.025-in. less than the outside radius of the Buckingham pinion; therefore, the clearance at B will be more with a standard pinion. In other words, if there is no interference using the Buckingham planetary there will not be any now. The difference of 0.025-in. between the root radius of the standard pinion and the Buckingham pinion also bears this out.

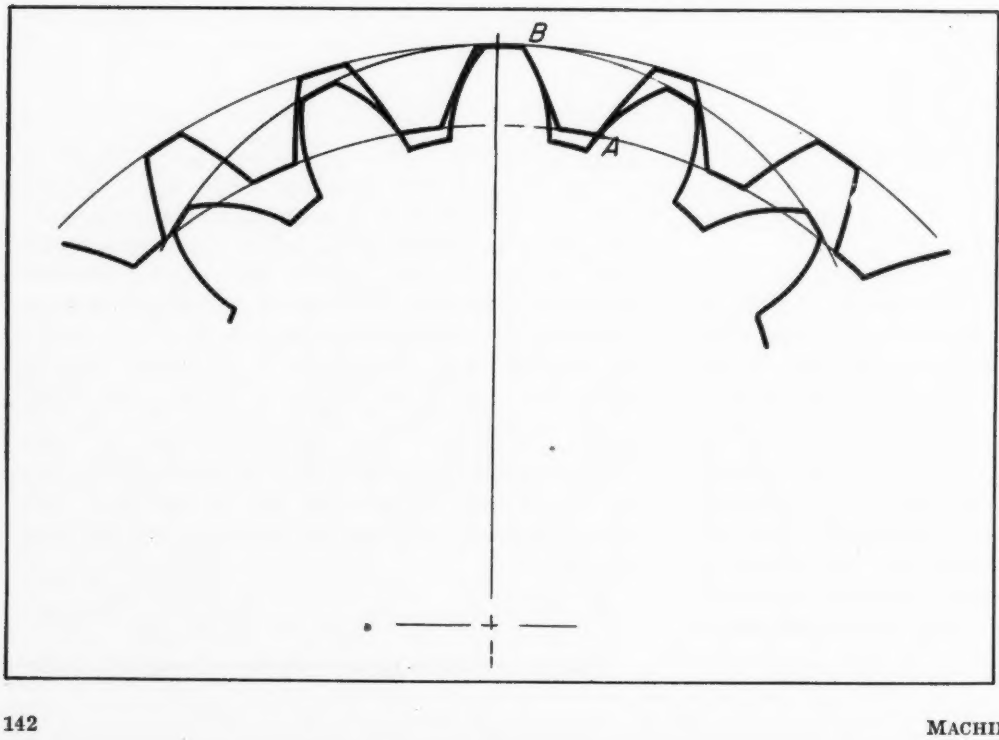


Fig. 2—Possible interference points are indicated at A and B. Standard pinion being smaller than Buckingham pinion provides more clearance

Magnesium Parts

may be hot-formed from sheet to produce deep draws economically in one operation

MAGNESIUM can be deep drawn and formed with facility at elevated temperatures. Draws may be made in one operation to depths, *Fig.* 1, which, in other metals, may necessitate a number of redraws and annealing operations. As a general rule, magnesium parts may be drawn in one operation to a depth of from one and one-half to two times the minimum diameter of the part. Single reductions of as much as 67 per cent are not uncommon.

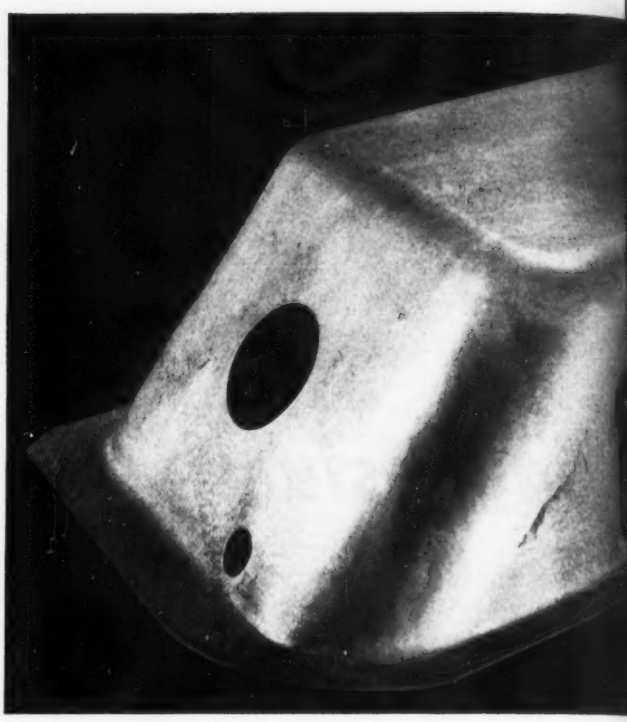
Most magnesium drawing operations occur within the plastic range and are characterized by a lateral flow of metal and sometimes by a change in section thickness. Working temperatures depend upon such factors as depth of draw, thickness of metal, radius of corners, and condition of the alloy. In general, temperatures vary from a minimum of about 300 F to a maximum of 650°F.

Hot forming is advantageous in that springback is reduced as the forming temperature is increased, being negligible at higher temperatures. At lower temperatures, the springback allowances that must be made will be governed by such factors as thickness of material, alloy used, radius of bend, and forming temperature. Also of interest is the fact that in those cases where die materials have a different coefficient of expansion than magnesium, it is possible to control the dimensions of a drawn part to some extent by temperature adjustment. This ability to correct the size of parts which deviate slightly from permissible tolerance limits may prove of consider-

Fig. 1—Hot-drawn magnesium parts, indicating the depth of draws possible in a single operation. At left center is an oil-tank head formed from 0.032-inch sheet. At right is a junction box and cover drawn from same thickness sheet. All parts are annealed M alloy

able value in some cases.

Some parts which require exceedingly deep draws can be made by multiple drawing the magnesium sheet. As careful control is required to make draws as deep as those shown in the accompanying photographs, it is recommended that the top limit for a draw be set somewhat lower than the maximum drawability of the alloy used.



Dies Usually Are Mild Steel

Forming dies for magnesium are usually mild steel although heat resisting cast-iron alloy is also being used successfully. Precaution should be taken to make due allowance for difference in coefficients of expansion when die materials other than magnesium are used. Punches may be steel, cast iron, magnesium alloys, or aluminum alloys.

Inasmuch as magnesium drawing operations are frequently performed at relatively high temperatures, the lubricant employed must meet at least two requirements—it must not burn and it must retain its lubricity at elevated temperatures. Colloidal graphite seems to meet these requirements as well or better than other materials used thus far. A satisfactory mixture for most operations is from two to five per cent colloidal graphite by weight suspended in a low boiling point naphtha, or in alcohol. A uniform black layer of this material is sprayed on the magnesium sheet.

The coating should be removed from the parts soon after they are taken from the press, this being accomplished by dipping the parts in a bath containing 15 to 20 per cent chromic acid and three per cent sodium nitrate. When sheet is to be used for forming, it should be ordered in the plain condition rather than the chrome-pickle since the pickle treatment removes the oxide film from the metal and the

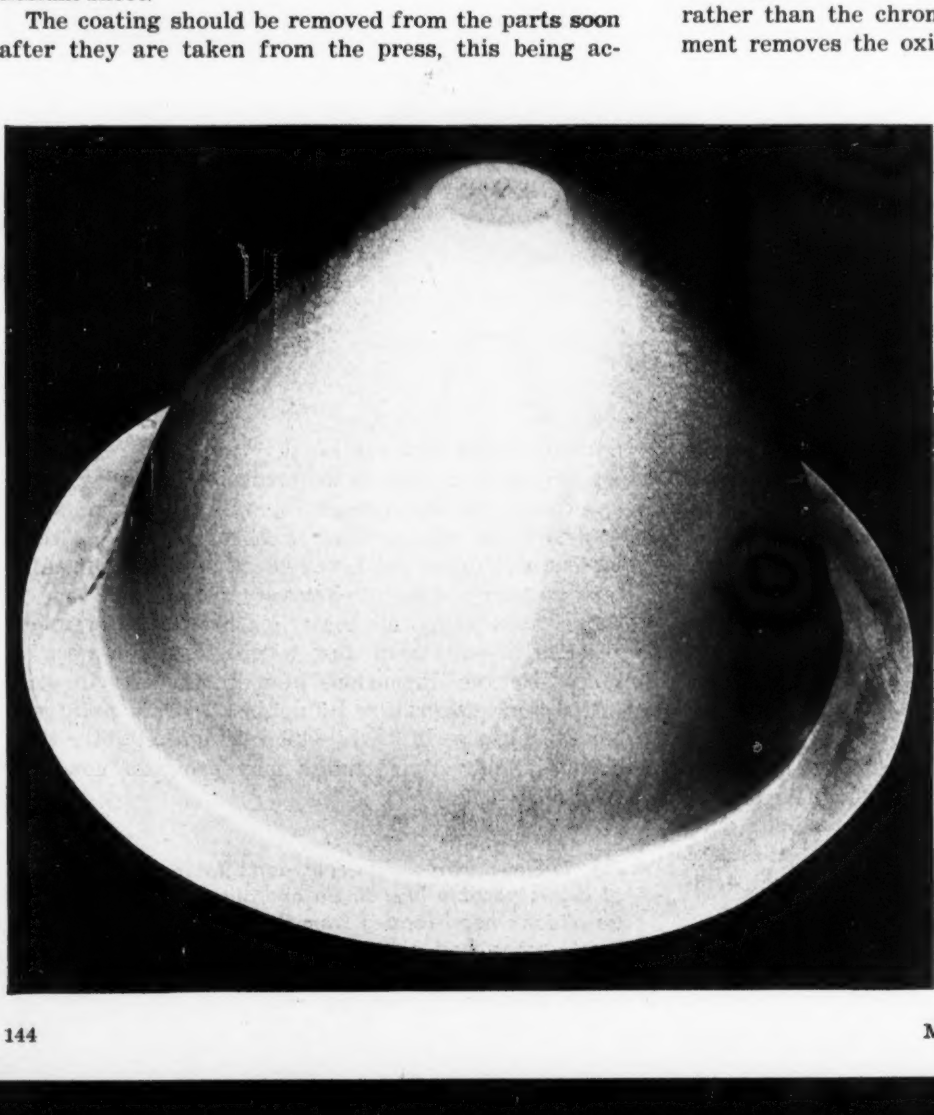


Fig. 2—Nose spinner formed by a single draw of hot-magnesium sheet on a heated die

Fig. 3—Power unit cover of magnesium hot-drawn in one operation on heated die

lubricant when sprayed on such a surface is hard to remove. If the sheet is to be stored prior to forming it should be ordered in the oiled condition.

In selecting the proper alloy for a magnesium formed part, the designer will be governed by such considerations as the requirements of the application, weldability, formability, the physical properties of the particular alloy, and cost. At present, two sheet and plate alloys are commercially available from the Dow Chemical Co., these being Dowmetal M and FS. Dowmetal M alloy is characterized by good formability, drawability and weldability, and is a good general-purpose alloy. Dowmetal FS has good physical properties and good formability. In the hard-rolled condition it is used in applications requiring a combination of high strength and toughness.

A wide variety of magnesium parts may be deep drawn, including such aircraft parts as nose spinners and dorsal fins, and many types of housings and containers. The nose spinner, *Fig.* 2, was formed by a single draw of hot sheet on heated dies. The spinner is 14½ inches deep and has an inside diameter of 22 inches at its base. As the tendency to pucker in a draw of this type is fairly great, it was necessary to draw the part at 600 F. Another drawn part, the power unit cover shown in *Fig.* 3, is also deep drawn to a diameter measuring eight inches and a depth of 16 inches.

Waffle Grid for Aircraft Wing

An interesting example of a magnesium stamped part is shown in *Fig.* 4. This "waffle grid" is used in the trailing edge panels of a B-36 bomber wing made by Consolidated Vultee Aircraft Corp. Dowmetal FS alloy is used, the material being 0.025-inch thick. The first operation consists of punch-pressing a series of holes primarily intended for lightening. The parts are stamped to the desired shape on a 300-ton mechanical press, the depth of draw being approximately ¾-inch.

For best results, there are a number of recommendations which should be followed when blanking, punching or shearing magnesium. For instance, the shearing and punching of magnesium sheet thicker than approximately 0.064-inch is apt to result in a rough, flaky fracture. This may be minimized, however, by using a shearing or rake angle of 30 to 45 degrees on the upper shear blade and by keeping the clearance between blades as small as possible without scoring the blades. A double shearing operation known as "shaving" may be used to improve the sheared edge. This consists merely of removing about 1/32 to 1/16-inch by a second shearing. For extremely smooth edges, sheared or blanked parts should be routed or filed. On some heavier gage magnesium, a much smoother edge can be obtained by shearing the sheet hot, but magnesium plate

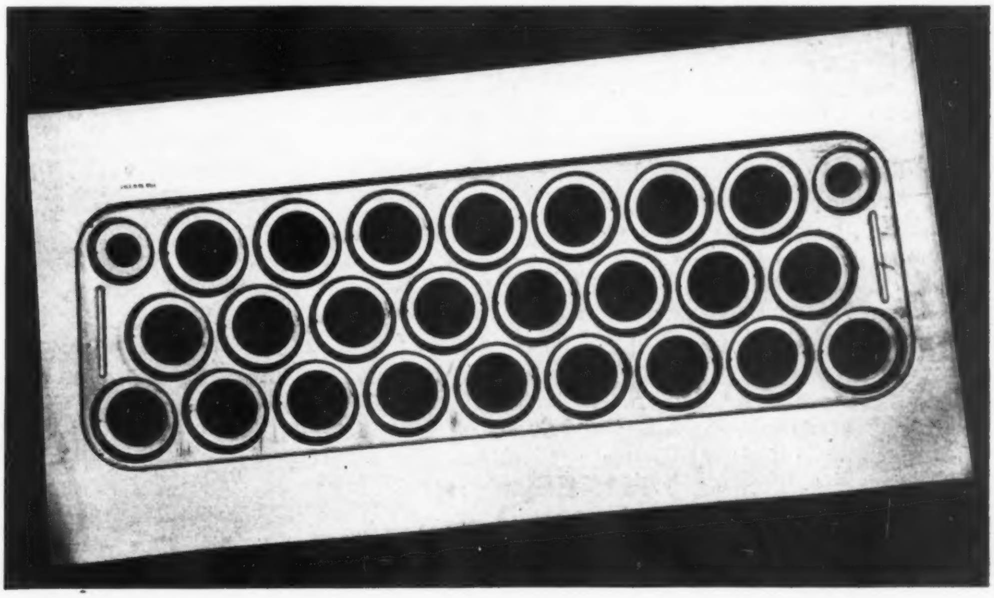


Fig. 4 — Magnesium waffle grid stamped and drawn to a depth of ¾-inch

heavier than ½-inch thick should be sawed rather than sheared. Blanking and punching operations on magnesium sheet are usually performed cold, for in punching heated material, trouble may be experienced because of the magnesium freezing on the punch.

Rubber Dies Are Useful

Widely used and of increasing importance in the shallow forming of magnesium parts is the Guerin, or rubber-forming process, in which a rubber pad is used as the female die and the work is bent to the shape of the male die. This process is advantageous from the standpoint of the speed with which small quantities of various shapes and sizes can be produced and also because of low die costs. Magnesium is frequently used as a die material in this process, being advantageous because it has the same thermal expansion as the work and no allowance therefore needs to be made for shrinkage. On long slender dies, however, it is not recommended, due to its tendency to creep upon repeated application of pressure and heat.

The Guerin process may also be used for straight bends with a relatively small radius. The usual types of brakes and bending rolls may also be employed for bending magnesium, the press-type brake being preferred to the leaf-type.

Other techniques are sometimes employed in forming magnesium and, although less frequently used than those already discussed, they nevertheless merit consideration. These are spinning, stretch forming and drop hammer forming. Spun magnesium is used for dust covers and hub caps, airplane propeller spinners, and similar applications. Standard spinning tools are employed and colloidal graphite or brown laundry soap serves as a lubricant. Stretch forming of magnesium has already been widely used and its success to date indicates expanded use of this technique. Magnesium is being successfully formed on a drop hammer and when only limited quantities are involved, considerable savings in die cost may be realized.

Analogy Chart Aids Design

BY USING concepts, relations, and methods of analysis developed at the Bell Telephone Laboratories for use in the design of feed-back amplifiers, its engineers were enabled to quickly design servos having performance rarely achieved previously.

Analogous relations are tabulated below. There are three main divisions: static, dynamic and kinetic. Within each division is a line for electrical quantities, another for linear mechanical quantities and a third for rotational mechanical quantities. These quantities are divided into five vertical columns. Relationships among them in any one line are exactly the same as those in any of the other eight lines. Drivers are listed in the second column and the direct results in the third. Opposers are in the fourth column and the "giver-uppers" or conformers in the fifth. Ultimate net accomplishments are shown in the first column.

Mathematically, the first column divided by the second gives the third, the second divided by the third gives the fourth, and unity divided by the fourth gives the fifth. Relations among the electrical quantities in one column are the same as the relations among the mechanical quantities in the same column. Current, for example, is charge divided by time, and velocity is distance divided by time. Momentum or impulse is the product of force and time and magnetic flux is the product of voltage and time. Some positions in the chart are left blank because there is at present no common name for those quantities.

		1 Net Accomplishment	2 Drivers	3 Results	4 Opposers	5 Conformer
Static:						
	Electrical	Potential energy	EMF	Charge	Elastance	Capacitance
	Mechanical	Potential energy	Force	Distance	Stiffness	Compliance
	Rotational	Potential energy	Torque	Angular displacement	Torsional stiffness	Torsional compliance
Dynamic:						
	Electrical	Power	EMF	Current	Resistance	Conductance
	Mechanical	Power	Force	Velocity	Viscous friction	———
	Rotational	Power	Torque	Angular velocity	———	———
Kinetic:						
	Electrical	Kinetic energy	Magnetic flux	Current	Inductance Permeance	Reluctance
	Mechanical	Kinetic energy	Momentum Impulse	Velocity	Mass	———
	Rotational	Kinetic energy	Angular momentum	Angular velocity	Moment of inertia	———

Designing for Welding

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Fig. 1—Enclosure for a residential heating boiler which exemplifies a well-balanced welded design wherein good styling is achieved without special welding or finishing

PROGRESS in the development of welding technique has been little short of phenomenal in recent years. Design for welding, though, has not made corresponding advances in as general a scope. This is, perhaps, partly due to the fact that technical knowledge was, to a great extent, principally developed as a postmortem of difficulties encountered in welding. However, at present, this problem is being attacked scientifically to determine, if possible, the limits of the applicable range for the various welding methods. Therefore, considerable improvement in the condition existing in the past and, to some extent, today can be expected, *Fig.* 1.

The economics of welded design, to a great extent, are an individual problem with each manufacturer. Further, in a great many instances, the characteristics peculiar to a particular industry as well as the characteristics required of the particular product in question also enter into the picture. Again, the problem may be further complicated by the facilities available in each organization, as well as the facilities located within a workable radius of the organization.

Regardless of the circumstances which may surround any particular design for welding, there are certain fundamental factors which must be recognized and observed in order to obtain the maximum economy and performance. These will be outlined and touched upon in the following to point up their importance in designing the most successful weldments.

Rules For Design

Eliminate welding where possible and use welding technique and equipment to produce the most economical result. Elimination of welding, wherever possible, is stressed because the cost of welding generally exceeds the cost of joints made by means of pressing or incorporated through the use of castings, forgings or pressings. The cost per pound of metal deposited by arc welding may vary from 70 cents to $3.00 per pound. This fact takes on more importace as the size of structure increases; it would take proportionally less time to bend or press a long plate to form an angle than to weld two plates.

Careful consideration should also be given to the amount of welding specified both for size and footage. In skip welding, the unwelded section generally should be greater than the length of the weld or otherwise the cost to break and start the arc will overcome the decreased footage.

The amount of welding can also be controlled by the

This article is based on a paper prepared for the American Welding Society.

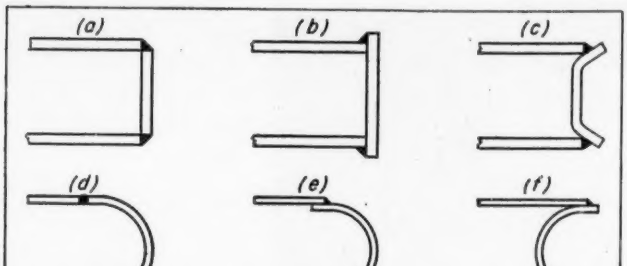
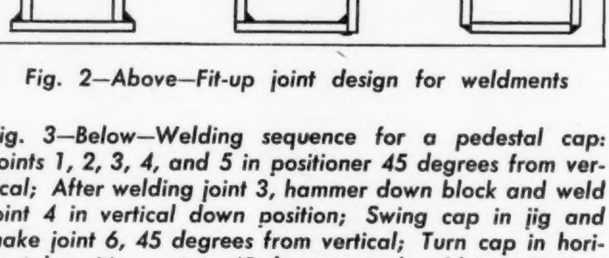


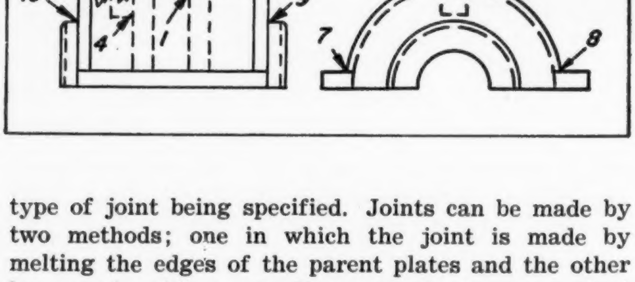
Fig. 2—Above—Fit-up joint design for weldments

Fig. 3—Below—Welding sequence for a pedestal cap: Joints 1, 2, 3, 4, and 5 in positioner 45 degrees from vertical; After welding joint 3, hammer down block and weld joint 4 in vertical down position; Swing cap in jig and make joint 6, 45 degrees from vertical; Turn cap in horizontal position, rotate 45 degrees, and weld joint 7, then turn 135 degrees and weld joint 8; Fit cap to base and weld on seals at joints 9 and 10



type of joint being specified. Joints can be made by two methods; one in which the joint is made by melting the edges of the parent plates and the other by use of welding rod. However, the former method will allow welding speeds approximately 80 per cent greater than with the latter method and, at the same time, decrease the electrode cost approximately 60 per cent. The type of joint specified must also be ample for the type of load and intensity of stress to be placed upon it. It is important to point out that in some cases a joint produced merely by penetration will not withstand fatigue loads as well as joints made by deposition.

Fig. 4—Small valve body made up from two forgings which are flash-welded together



When welding must be ground to improve appearance, the grinding may radically affect cost and, therefore, a bend made by use of dies is economically desirable. Also, when working with materials such as stainless, fabrication by pressing may decrease the finishing cost considerably over that when welded areas must be refinished. However, with bending or pressing, it is important that proper material be furnished to obviate cracking in the bending operation. This requires not only specifying the material to obtain the proper ductility but also the forming codes to which the plate should be rolled, for instance, cross-rolled. Wherever possible, bending or pressing should be done cold for lowest cost, as well as for better fit-up without resorting to straightening. However, forming cold requires proper contours and in simple right-angle bends, one to two times the metal thickness is used for inside radii.

It should also be borne in mind that the total welding cost depends on three factors: (1) Preparation; (2) welding; (3) finishing. In preparation, the plates may be sheared or torch-cut but may produce poor fitups so that the welding and finishing costs may increase and, therefore, in instances where the type of tools to be used for shearing or torch cutting are not precision, it may be economically feasible to machine the weld preparation and, thereby, obtain the lowest overall cost. It is also possible to make special joint preparations by machining so that larger electrodes can be used and thereby actually decrease the total welding cost through the greater rate of deposition obtained in the welding operation.

Use materials of maximum weldability. If special alloys are required, use only where necessary. Most metals can be fabricated by welding; however, some metals require considerable care in preparation before welding as well as during and after welding, which increases the cost appreciably. Metals such as the open-hearth steel require little preparation and minimum skill in welding and should, whenever possible, be used to assure lowest costs. Some of the richer alloys may also be welded with great ease if the proper method is employed; for example, flash or butt welding. However, these methods are limited to cases where special setups are economically feasible because of the quantities involved.

Brittle Material Requires Care

Ductility in the metals being welded is an important factor. Ductile materials allow welding distortion to take place without causing injury to the structure. On the other hand, a brittle material produces stresses which rapidly rise to rupture values with very small values of distortion. For this reason, great care must be taken to eliminate residual stresses in the latter materials.

Produce designs where good fitup is easily obtained and, at the same time, will not require excessive amounts of welding. The fact should always be borne in mind that any manufacturing process must have tolerances to allow for variations in the performance of the fabricating equipment used before final assembly by welding, as well as in the welding operation. It should

be borne in mind that the closer the tolerance requirements the greater the cost.

Ingenuity in design will make it possible for plates to lap over each other on the unimportant dimensions of the structure and decrease labor necessary to obtain good joint fits. The effect of poor fitup on cost is such that welding speed is reduced 65 per cent when welding on $\frac{1}{8}$-inch material with a gap equal to the thickness of the material. On $\frac{1}{2}$-inch material, the same joint speed is reduced 75 per cent with a gap equal to one-half the thickness of the material. Good joint fit-up design which obviates maintaining close tolerances on fabricated parts is shown in *Fig.* 2. In *Fig. 2a* is illustrated either a circular or rectangular flat-end vessel. Dimensions on the diameter, or across the plates of the vessel, must be held to close limits, and the ends of the longitudinal member must be square. Further, the end plate must be maintained close to dimension and flat as any large clearance results in bad fitup and, consequently, creates difficulty in building up welds. This type joint is difficult to use with automatic welding.

Thermal Capacity Important

Conditions with respect to dimensional tolerances on the plates are improved in *Fig. 2b,* but the longitudinal plates must still be square and the end plate flat. However, more thermal capacity is provided at the gaps, if any exit, making it easier to build up. This joint is much more desirable for automatic welding.

The end plate of *Fig. 2c* is a shallow pressing. In assembling, it is only necessary to tap the end plate into the vessel until it is tight all around the periphery and thereby produce excellent fit-up for either manual or automatic welding. The same analogy for a tank with spherical ends is illustrated in *Fig. 2d, e* and *f*. Stress conditions should also be considered, as stress flow in joints shown in *Fig. 2c* and *f* are not desirable unless stresses are of low value.

Parallel plates whose dimensions must be maintained are shown in *Fig. 2g, h,* and *i*. In *Fig. 2h,* all plates must be close to dimension and square, but in *Fig. 2i* there is no need for keeping any of the plates to close tolerances as they lap each other and can be assembled to obtain the proper dimensions. Good joint fits decrease the amount of welding required and also produce less distortion in the structure during welding.

Considerable latitude in tolerance on the final product is possible in the welding operation itself by standardized procedures and by use of proper welding jigs. In setting standards, information, such as type electrode, electrode size, current, voltage, type of welding equipment, size of weld, number of passes, welding position, welding arc speed, etc., should be given. In automatic arc welding, size and type of flux should also be given. When other forms of welding are used, such as gas, inert arc, resistance, etc., pertinent data should be given as to manipulation of the equipment to obtain uniform results. In addition to the foregoing information, a fabrication

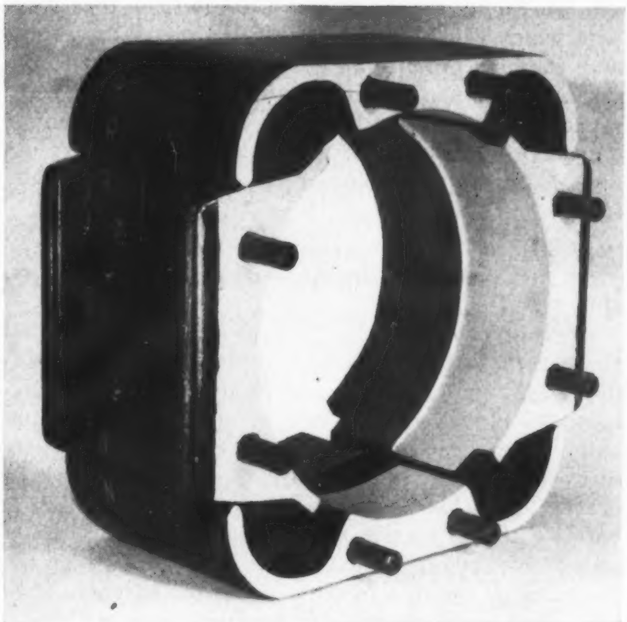


Fig. 5—A journal box which is made from four forgings which can be automatically or manually welded together

sequence should also be supplied showing the chronological order in which the various elements should be added to the assembly, how they should be clamped or tack welded, as well as in what sequence each should be welded, *Fig.* 3.

Use as few elements as possible to compose the weldment consistent with quantity being produced. In a great many instances, considerable cost reduction can be accomplished by taking several elements comprising a weldment and making them integral in the form of a pressing, forging, or a casting. This will eliminate a considerable amout of welding and set-up cost, as well as fabrication and assembly cost. In a good many instances, it is possible to redesign so that a unit can be made from several cast elements which can be welded together and decrease the cost over casting as an integral unit. This is made possible by eliminating core work necessary when making the integral casting.

Two interesting examples following this analogy are shown in *Figs.* 4 and 5. Forgings, *Fig.* 4, for small valves are later flash welded to make the valve hous-

Fig. 6—Journal box which utilizes castings, forgings, pressings, and torch-cut bars for economy and function

ing. In *Fig.* 5, a journal box is made from four forgings which can be automatically or manually welded and, thereby, produce an economical product with decreased weight, eliminating rejections due to porosity found in an integral casting. Further, economy is gained in elimination of machining external surfaces and also reducing machining required on interior surfaces.

Composite Design Advantageous

Another example, *Fig.* 6, shows a welded journal box which utilizes a design approach wherein castings, forgings, pressings, and torch-cut bars are combined to reduce the number of elements to a minimum. This procedure assures a box with minimum distortion and, at the same time, makes it possible to eliminate machining formerly required. Further, it is possible to use materials with desired physical properties only where actually required, such as in the top member where a forging of greater hardness than the other members is used to resist peening forces due to pounding action of the bearings.

Design so that as little handling as possible is necessary during fabrication. Oftentimes a design can be made so that all joints can be reached from one side of the weldment, making it unnecessary to turn the unit over to weld all the joints. Use of positioners to properly support and rotate the structure being fabricated will assist in reducing handling time and minimizing movement by the operators in welding.

Eliminate as much direct labor as possible in producing the welment. An important consideration, not only in the welding field but industry in general, is elimination of as much direct labor as possible in production operations. This fact is gaining more importance as the cost of labor is increased and at the same time productivity often decreased.

There are several types of joints which can be produced with considerably less welding and fabrication labor. In some instances, a substantial decrease in welding cost is produced with a small increased fabrication cost and, therefore, for most economical results should be used. This factor is especially important on heavier members. In addition, new equipment, such as the semiautomatic welding machinery and inert gas-shielded arc, produce joints with considerably less joint-preparation cost. However, in the latter, precision fabrication is necessary so that good fit-up is obtained. A joint procedure, *Fig.* 7, gives pertinent engineering data as to dimensions, strength and location.

Eliminate machining and straightening operations on the final weldment to greatest extent possible. Economy may be obtained by eliminating subsequent operations such as machining. It may be possible to eliminate one rough cut over that required with a casting and, in many instances, it is possible to eliminate machining entirely. Further it is possible to produce holes by punching in the fabricating operations instead of drilling as required on a casting.

When using forgings or castings as elements, care should be taken that parting lines are most advantageously located to reduce preliminary machining or grinding operations. With forgings, use should be made of sheared faces produced by the trimming operation to obtain better welding fit-up. When possible, forgings with important faces, which must be flat and smooth and ordinarily would be machined, should be designed so that these faces are perpendicular to the stroke of the forge hammer and in the top die to insure the best flow and freedom from slag or dirt. Subsequent coining operations will generally prove economical by providing faster and better fit-up.

Fig. 7—Joint design selection table showing necessary weld dimensions, strength and location data

Section	Welding Symbol	Thickness T	Root Opening A	Bevel Angle B°	Reinforcing 2-in.	Max. Eff. %	Application
		1 3/4	3/16	80	1/4	100	Use for all loads
		3/4	1/8	60	1/8		
		3/4	5/32	60		70	F_1, F_2, F_4 may be static or moderate dynamic loads. F_3 moderate static loads only.
		1/4	1/16	40			
		3/4	5/32	60		80	Use for all moderate static and dynamic loads.
		1/4	1/16	40			
		3/4	5/32	60	5/32	80	Use for moderate static and dynamic loads except F_3 use only static and light dynamic.
		1/4	1/16	40	3/32		
		3/4	5/32	60	5/32	90	Use for all loads.
		1/4	1/16	40	3/32		
		1 1/2	5/32	60		60	Use for all moderate static and dynamic loads.
		1/2	1/16	40			

Stress relieving should be resorted to only when necessary from a safety, load-performance or dimensional-stability standpoint. It should be borne in mind that a weldment will age much the same as a casting and, if possible, should be allowed to do so even though it has been stress relieved when extreme precision must be maintained on finished structures.

When using medium carbon, alloys or open-hearth materials, the structure should be normalized to reduce machining difficulties. In many instances, a stress-relieving operation can be combined with a normalizing operation by using the same heat cycle to accomplish both objectives and reduce operational cost.

Make joint design so that stresses are well balanced. An important factor from the standpoint of performance as well as of cost is one of placing the welding so it does its work most efficiently. When static loads are anticipated, complete penetration may not be required with heavy plate. However, insufficient amount of welding will not produce a single mass but rather a complex problem of several masses acting under dampened conditions from adjacent members. Further, the welding should be, where possible, placed so that it will not develop stress raisers by discontinuities characteristic of the welding technique, that is, change in ductility, undercuts, excessive build-up, etc. Unbalanced joints under several types of loads and also suggestions as to how they can be improved are shown in *Fig.* 8.

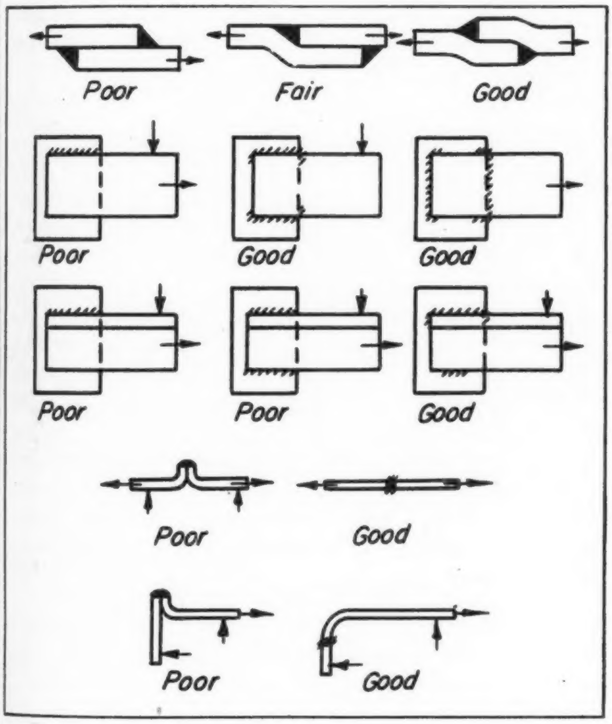


Fig. 8—Above—Group of unbalanced joints and suggestions for obtaining more efficient and satisfactory design

Design so that welding is uniform about the neutral axis of the structure, as well as of each joint. Welding procedure and fabrication sequence can materially influence the amount of welding necessary. Structures can be welded in two broad classifications; one producing high residual stresses and small distortion and the other low residual stress with considerably greater distortion. In the former, care should be taken that weld beads are ample to resist the residual forces set up. To hold down distortion and also to decrease the stiffness necessary in jigs, the design should be such that welding is uniform about a neutral axis through the structure. It is also helpful if the same theory is followed at each joint. For instance, a butt weld between two members produces less distortion than the same two members being welded together by a fillet weld. The same thing is true of a disk being welded into a ring where a V-joint is used in place of the fillet weld.

Residual Stresses Must Be Minimized

The suggestions just given indicate that the fit-up cost may increase when resorting to these practices. However, if production requires precision and freedom from warpage, this procedure must be employed to obtain the results required. It is possible, when necessary, to use a small filler made from a material with a low yield point and high ductility, such as a copper wire. The latter is useful on heavy sections to reduce the amount of residual stress on the welds and still maintain small root openings to minimize distortion.

The remark, "the weld is stronger than the parent

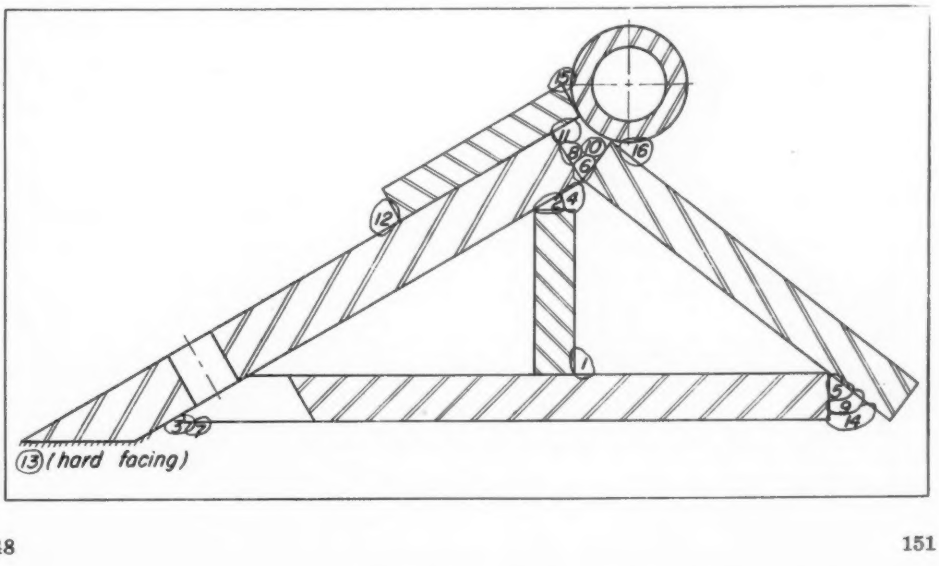


Fig. 9—Right—Section of a weldment with inadequate accessibility and joint conditions at beads 2, 5, 11, and 16

plate", is frequently made but does not always prove to be true, and generally inadequate provisions for taking care of residual stresses account for its undoing.

Study each joint from a metallurgical and stress performance standpoint. Also, wherever possible, make the joint design so that requirements of the welding technique and operator's skill are held to a minimum. The thermal capacity of the material at the joint should be studied when determining the size of weld to be specified. Further, on multiple-pass work, it is important to specify the size of the first pass so that undue cooling rates will not exist. These tend to set up brittle deposits at the root of welds and, when stressed, act as stress raisers. Conversely, it is also important that excessive welds are not specified for the thermal capacity of the joint involved, as excessive oxidation may also decrease the physical properties of the joint.

When welding some of the special alloys, the size of welds specified is important from the standpoint of maintaining the original characteristics of the parent alloys. Improper heating caused by the welding will, in some cases, destroy the properties originally intended but, in most cases, they can be restored by heat treatment. In the latter case, it is important that the most suitable equipment is used not only to maintain the metallurgical properties but also to reduce the operator skill required so that more uniform results can be obtained in production.

Another important consideration in this respect is that of providing sufficient accessibility for welding and also proper joint conditions to get satisfactory stress flow and metallurgical characteristics. *Fig.* 9 illustrates an assembly where joint conditions and accessibility are not the most conducive to good results at beads 2, 5, 11, and 16.

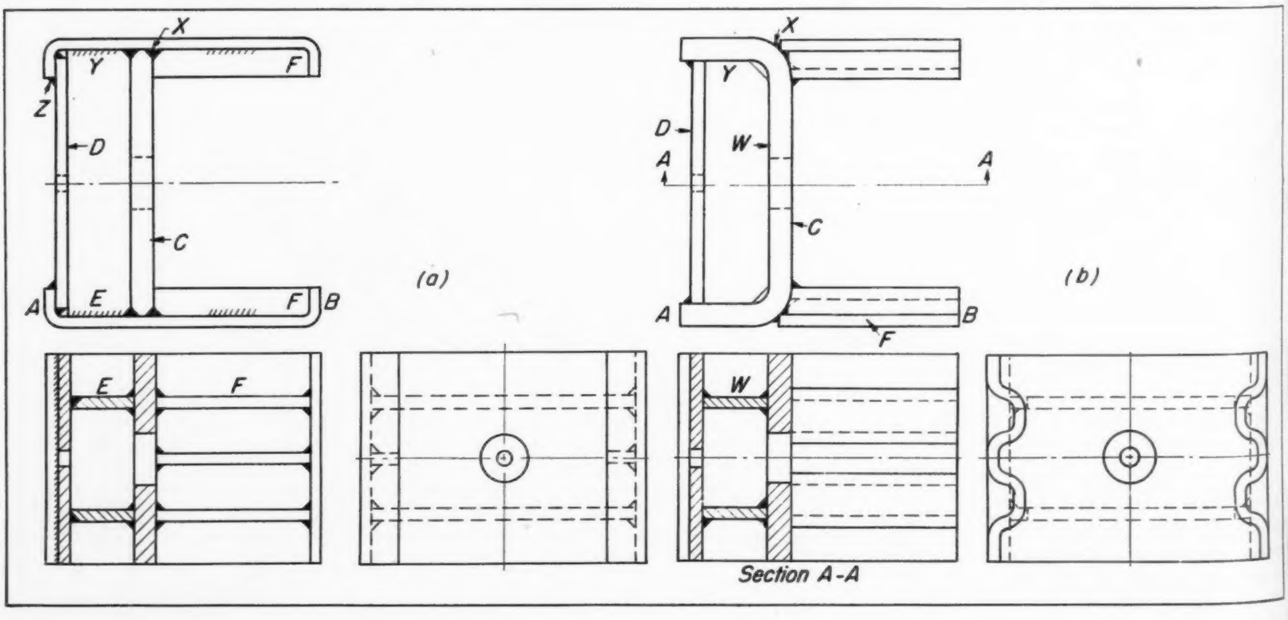
Study the design to determine if it can be readily handled on equipment to be used by the shop organization. After all considerations have been made, a design should be thoroughly checked to determine that adequate equipment will be available to produce the weldment at acceptable cost and with acceptable quality from the standpoint of performance, as well as appearance. A weldment as received for quotation is shown in *Fig.* 10*a*. It was necessary that ends *A* and *B* should be exactly to length and in parallel planes. Further, a load of ten tons was to be placed on plate *C* and 1½ tons on plate *D*. Loads at joints *A* and *B* were to be ten tons each and, therefore, ribs *E* and *F* were added to provide the necessary stiffness.

To take care of these loads, heavy welds were necessary at positions *X*, *Y*, and *Z*. Further, it would be necessary to specify rigid tolerances on side pressings at *A* and *B* with a good possibility of a machining operation being required at these positions later. Further, the heavy welding at *Y* and *X* will tend to warp plates *C* and *D* which had to be flat and parallel to faces *A* and *B*. This design required 12 members and 25 feet of single-pass welds.

Welding Reduced By One-Half

The redesign, shown in *Fig.* 10*b*, requires six members and 12½ feet of single-pass welding. Further, plate *C* is formed as a hot pressing thereby producing a flat surface at *C*. The two ends are torch-cut simultaneously. Large welds at *X* and *Y* are not required and, therefore, distortion could be minimized. In the welding, plate *C* is placed in a jig located from *A*, and sideplates *F* are located in the same jig from *B*. Welding at *Y* is completed before welds at *W* are made to reduce residual stresses otherwise imposed on this weld. It can readily be seen how the cost would be reduced with the new design and at the same time result in a better product without resort to machining.

Fig. 10—Below—Weldment design as originally received for quotation (a) and redesigned weldment, shown at (b), which requires one-half the number of parts and welding



Customer Needs Come First

Progressive designers never fail to take into account the specific needs of the customer. Their aim is performance, production at low cost, ease of control and maintenance, and numerous other vital factors which affect the acceptance of a machine, rather than the ultimate in mechanical perfection.

Just as individual tastes differ, however, on most other matters, so do they vary in connection with the choice of machines and appliances. Whereas potential users increasingly are placing the matter of appearance in the forefront in their selection, there are still many prospective buyers who consider utility value as the primary consideration.

This matter of individual reaction cannot readily be solved by the designer alone, nor is he likely to be assisted accurately in all cases merely by obtaining the help of the sales department. Valuable ideas for incorporation in design often are forthcoming from this source, but a completely rounded-out picture is desirable before the designer goes ahead.

Comprehensive user research has been found to give the only adequate answer to this problem. The wider and more far-reaching the scale upon which such research is carried out, the better the results. Often the engineering department is able to conduct its own research through visits throughout the field; in other cases the company may collaborate with colleges or other institutions to obtain essential data; and in still other instances the project is placed in the hands of research consultants who carry out market studies and competently interpret the results.

Particularly effective have been the efforts of the Ford Motor company in seeking user reaction. No opportunity is lost to gage possible consumer acceptance. Even at the recent demonstrations of 1949 Ford cars, a mock-up was utilized to obtain potential driver's reactions to the locations of controls and instruments, position of driver's seat, type and tilt of steering wheel and other factors having to do with driving comfort and control. Ford also has placed numerous other projects in the hands of universities. All user reactions are recorded, providing a wealth of background information.

Whether the ideas and suggestions of potential customers can be incorporated in final designs is a matter dependent solely upon careful appraisal of all pertinent factors. The fact remains, however, that the most successful design is that which is developed in accordance with the predetermined wishes of the highest and most influential number of potential users.

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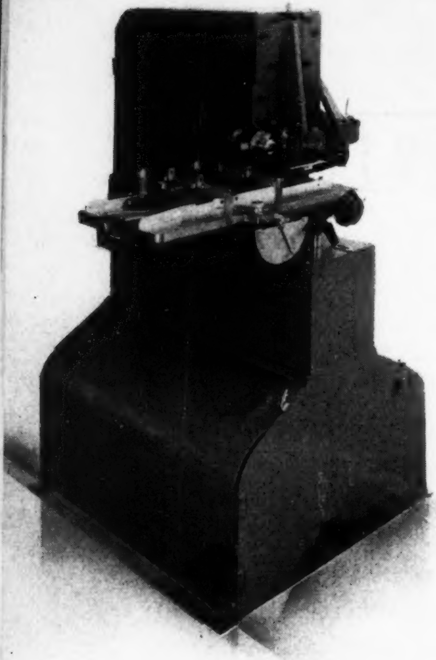
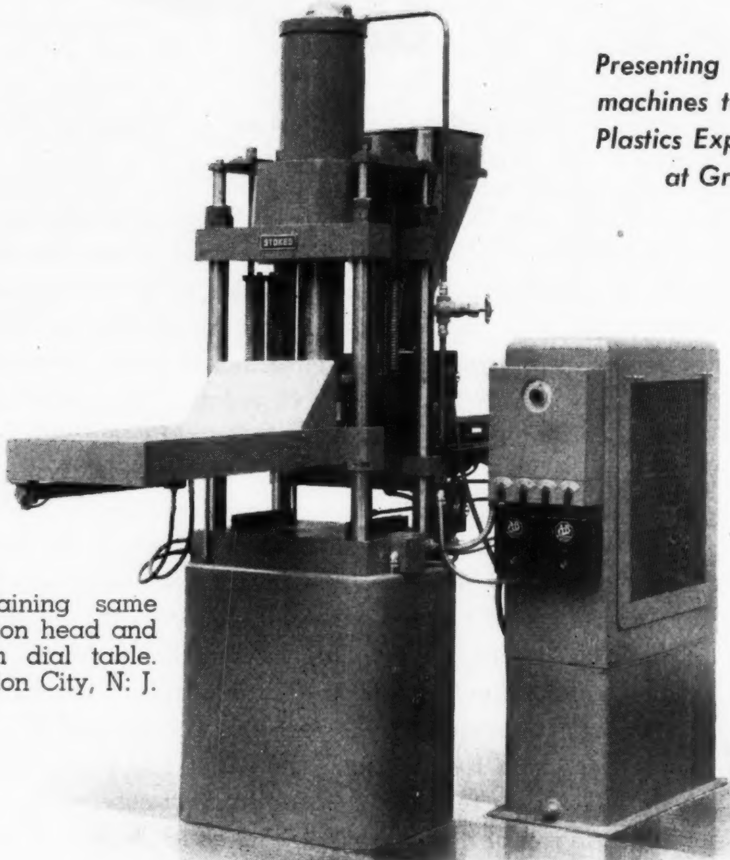
New Machines Fo

Presenting a representat secti machines to be exhibited Third Plastics Exposition, Septe to O at Grand Central Pa New Y



Above—Roll leaf stamping press trade marks or decorates surfaces of parts; pivoted-lever arrangement permits increase or decrease of stamping pressure while retaining same "dwell" on work; utilizes combination head and chase; has chain-fed, eight-station dial table. Mfr: Peerless Roll Leaf Co. Inc., Union City, N: J.



Above — Fifty-ton compression molding press automatically feeds, cures, ejects and takes away molded pieces. Sequence operated, in event of trouble during molding cycle the press automatically stops. Mfr: F. J. Stokes Machine Co., Philadelphia 20, Pa.

Below—Hydraulic injection molding machine has welded steel base with integral oil reservoir; hydraulic units mounted outside base at rear; mold spacing adjustable by central screw; automatic ejection by two push rods; cylinder heated by electrical resistance bands. Mfr: Reed-Prentice Corp., Worcester 4, Mass.

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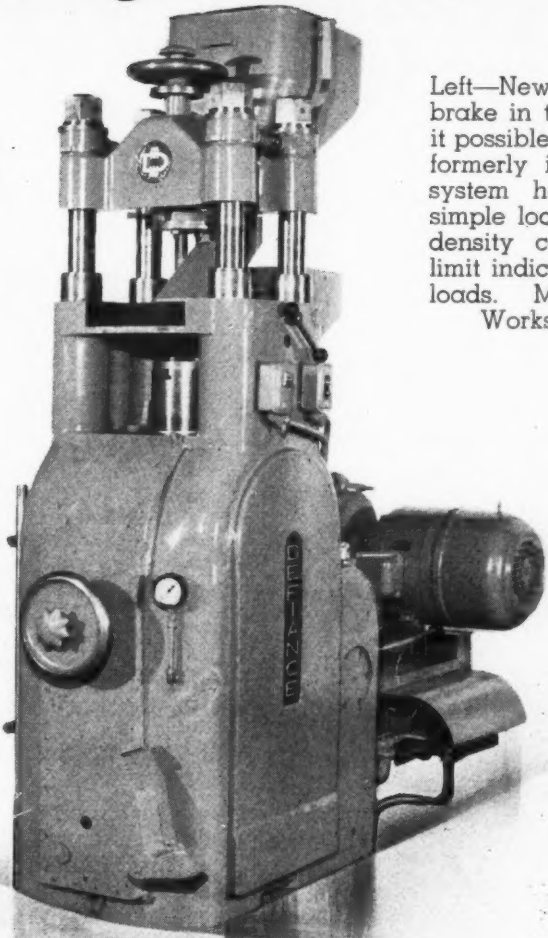
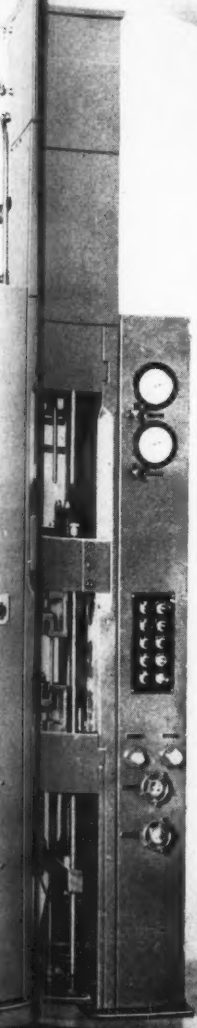


Left—New combination clutch and brake in this preform press makes it possible to preform fine powders, formerly impractical. Lubrication system has interlocking control; simple lock device insures fill and density constancy, and pressure limit indicator warns against overloads. Mfr: Defiance Machine Works, Inc., Defiance, O.

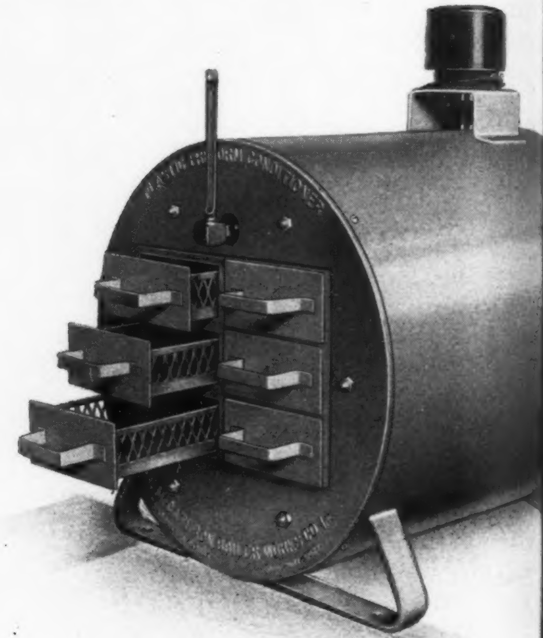
Above — High-frequency preform heater. Heating cycle control is manual or automatic; dual timers govern heating cycles in selected sequence; fumes and vapor from heated preforms are exhausted at rear; heating compartment is illuminated; lower electrode is an aluminum plate while the upper electrode is stainless steel wire mesh. Mfr: Thermax Div., The Girdler Corp., Louisville, Ky.

Below—Hydraulic injection press; all-steel welded construction; thermostatically controlled two-zone heating cylinder; manually operated through two-lever four-way control valve; pressure adjustable from 300 to 1500 psi; automatic parts ejector. Mfr: The Van Dorn Iron Works Co., Cleveland 4, O.



Left—Inverted-ram transfer molding machine is automatically cycled. Bottom cylinder actuates transfer plunger while bottom platen maintains constant level. Produced in three clamping capacities: 100, 200 and 300-ton. Mfr: Watson-Stillman Co., Roselle, N. J.

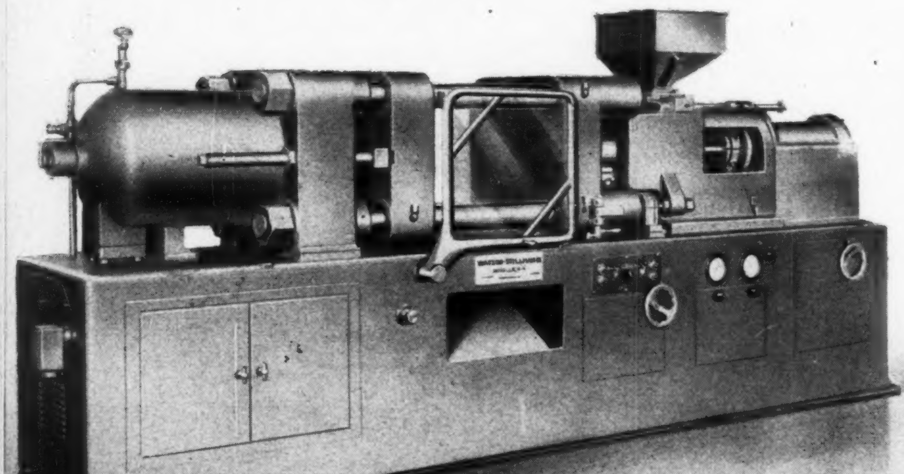
Left—Electronic preform heater. Equipped with loading board to handle multiple preforms; time control is automatic electric resetting type; dual safety interlock switches protect operator against injury. Mfr: W. T. La Rose & Associates, Inc., Troy, N. Y.

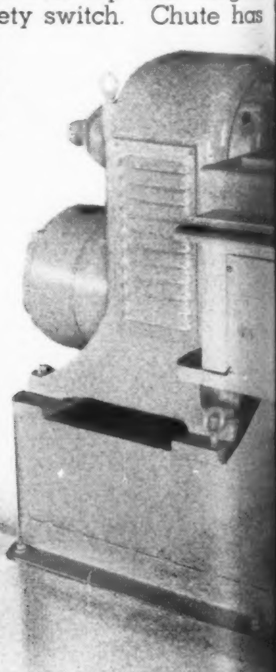


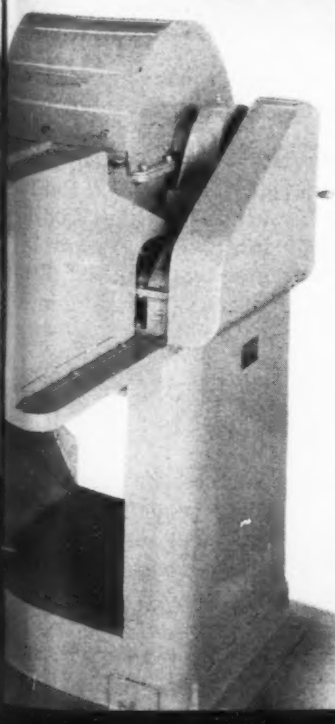
Above — Six-drawer preform conditioner heats and steams preforms prior to molding. Heat in preform chamber created by steam in jacket; humidifier with pressure-reducing valve regulates amount of steam entering chamber. Mfr: The McCathron Boiler Works Co. Inc., Bridgeport, Conn.

Right, below—Heavy duty rotary chopper cuts all types of milled or extruded plastics into 1000 pounds of pellets per hour. Balanced rotor is steel forging; has adjustable knives. Housing is welded steel with top half hinged and equipped with safety switch. Chute has electrically vibrated screen for removing "fines". Mfr: National Rubber Machinery Co., Akron 8, O.

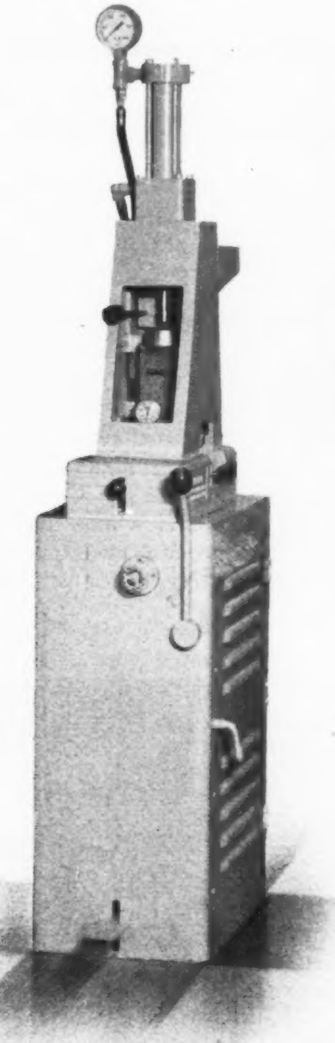
Below—Hydraulically operated horizontal injection molding machine. Manually or automatically cycled; adjustable speed and pressure control of injection ram; self-sealing heating cylinder with zone control; interchangeable injection cylinders. Mfr: Watson-Stillman Co., Roselle, N. J.

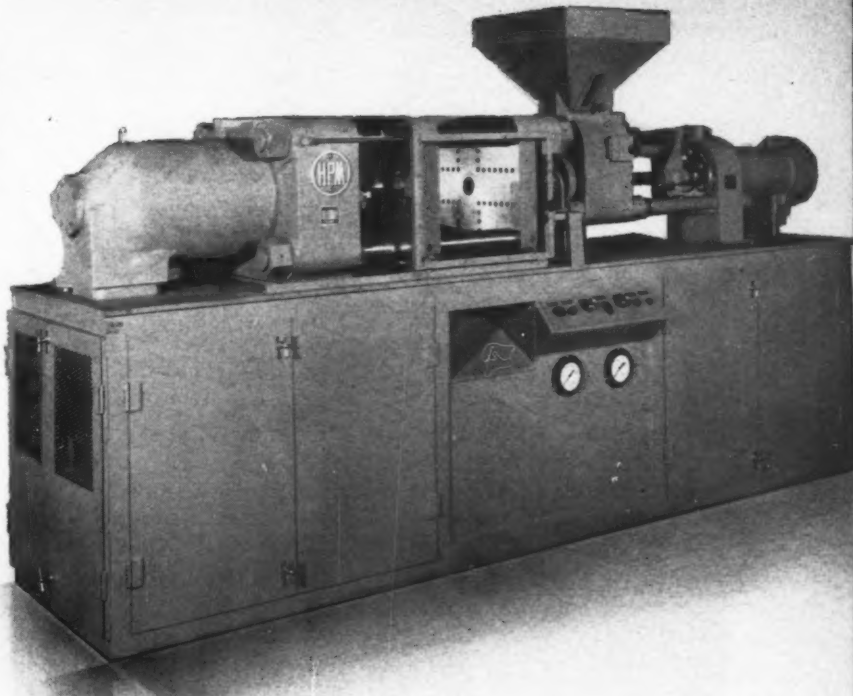






Below—Hydraulic injection molding machine—$^3/_4$-oz. capacity—has metering-type hand-operated hopper, a-c heating element, thermostatic control, and hand and foot-operated die knockout. Mfr: Moslo Machinery Co., Cleveland 15, O.



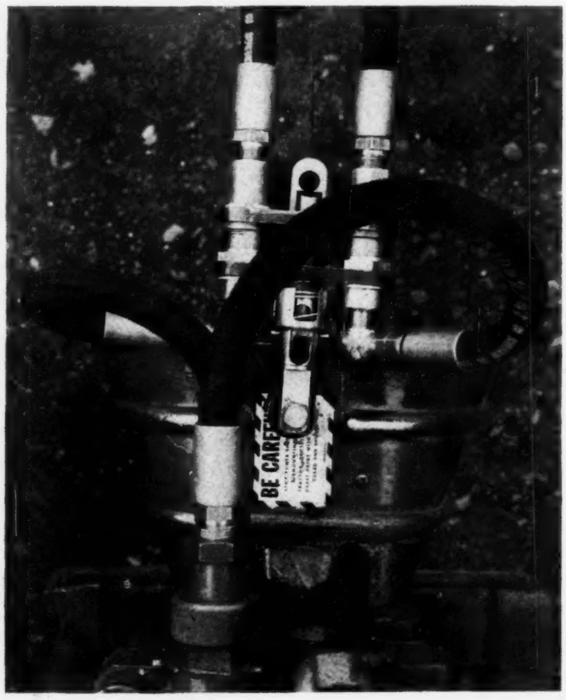


Above—Hydraulic injection molding machine. Manual and semiautomatic control; mold clamp assembly actuated by double-acting ram; chrome plated injection chamber has two-zone heating system; is gravity fed. Mfr: The Hydraulic Press Mfg. Co., Mount Gilead, O.

Right—Preheating unit heats and tumbles granular plastic materials prior to molding. Material is worm fed from hopper into drum which rotates inside heating chamber; chamber is heated through convection by resistance heaters; stainless material used for all heating chamber components. Mfr: Leiske Machine Co., Milwaukee 2, Wis.

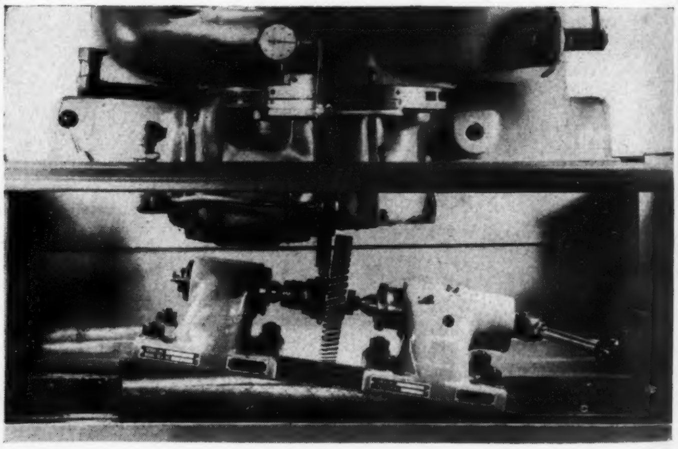
Applications

of engineering parts, materials and processes



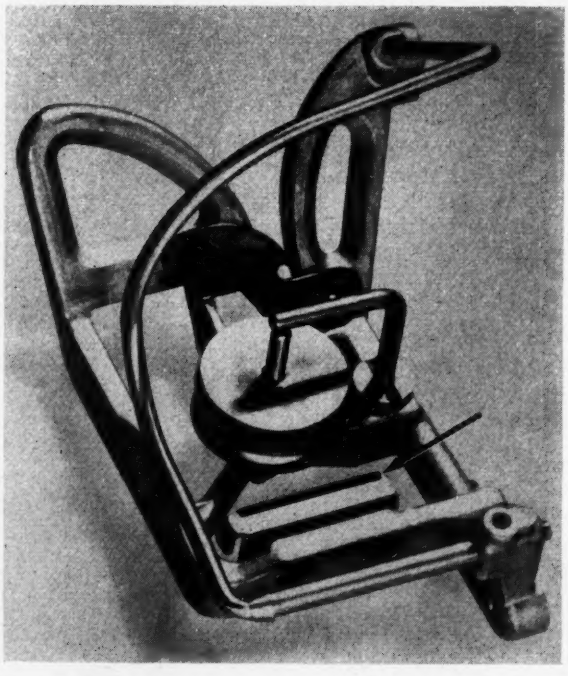
Coupling Releases Automatically

BREAKAGE danger involved with hydraulic lines joining tractors and drawn implements has been eliminated by the use of the Breakaway coupling, installation shown at left. This Aeroquip coupling is a twin unit connecting both pressure and return lines, using self-sealing couplings mounted in a frame and held in coupled position by means of a mechanical latch. External tug or manual operation of a latch disconnects lines without pressure being lost.



Gear Costs Lowered

DIFFICULTY of shaving shoulder gears to close clearances has been greatly reduced by the use of a conical involute cutter. This National Broach & Machine Co. development, as seen above, permits large cutting angle between cutting gear and work gear and therefore excellent cutting action. In setup shown, clearance is only ⅛-inch, yet machining time is relatively short.



Insert Resists Wear

USED as inserts in the wearing surfaces of yarn winding machine anvils, left, Carboloy cemented carbide shows no wear after more than a year of service. In contrast, abrasive yarn wears out the hard faces of conventional anvils in a few weeks time.

Intermittent Mechanisms

By Guy J. Talbourdet
Research Division
United Shoe Machinery Corp.
Beverly, Mass.

Part I

REPRESENTING A SIGNIFICANT ADVANCE in the design of machines requiring intermittent motions, the mechanisms discussed in this Data Sheet have been successfully used at high speeds. First of a three-part series, the presentation is based on a recent ASME paper. Formulas and charts show the characteristics of the output motion

INTERMITTENT variable-speed mechanisms can be successfully used at relatively high speeds, with appreciable inertia of the driven member, provided the forces acting on the driven members are gradually applied and removed during the periods of acceleration and deceleration. To obtain these desirable features, the motion of the driven rotary member should meet the following requirements:

1. Negligible acceleration at the start
2. Gradual change in acceleration
3. Smooth change from acceleration to deceleration
4. Gradual change in deceleration
5. Negligible deceleration as the rotating body comes to rest

This data sheet presents descriptions and equations for the motion of several intermittent variable speed devices in which these features have been incorporated. They have proved of real value in the design of turret indexing mechanisms and in many other applications. Discussion is confined to cases where the input shaft speed is constant, and deflections of the moving parts are ignored.

To bring out the basic principles used in the analysis, consider the planetary gear system shown in *Fig.* 1, in which internal sun Gear S_2 is driven at uniform speed, cage A carrying planet pinion P is given a variable motion and sun pinion S_1 is the driven output member.

Using velocity vector and instant center methods of attack, it can readily be visualized that the output sun pinion S_1 remains stationary only when instant center I is at pitch point C of sun gear S_1 and planet pinion P, as shown in *Fig.* 1. Then when $\omega_{s1} = O$

$$V_A = \frac{V_{s2}}{2} \qquad (1)$$

$$\omega_A = \frac{\omega_{s2} R_{s2}}{2R_A} \qquad (2)$$

For condition $V_A > V_{s2/2}$, the sun pinion rotates in the direction of internal sun gear S_2 because instant center I lies on centerline OO_p and between pitch point C and center O. From the geometry of *Fig.* 2

$$V_{s1} = 2V_A - V_{s2} \qquad (3)$$

$$\omega_{s1} = \frac{2\omega_A R_A - \omega_{s2} R_{s2}}{R_{s1}} \qquad (4)$$

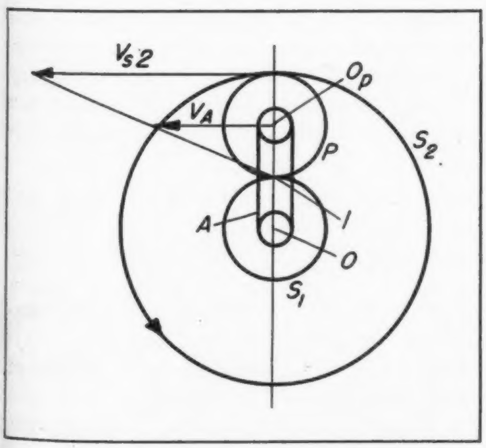


Fig. 1 — Left — Output sun pinion of planetary mechanism will be stationary if instant center I coincides with pitch point of sun gear and planet pinion

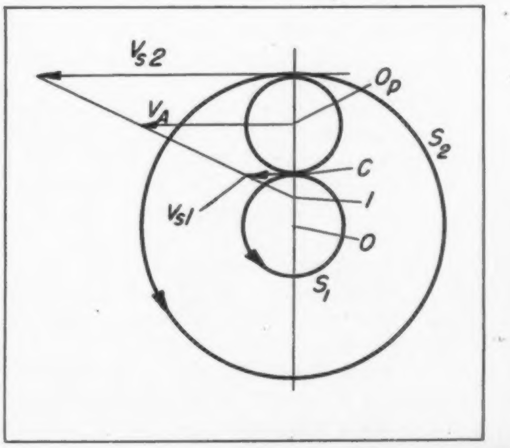


Fig. 2—Right—When arm speed V_A exceeds $V_{s2}/2$, sun gear S_1 rotates in same direction as gear S_2

ENGINEERING DATA SHEET

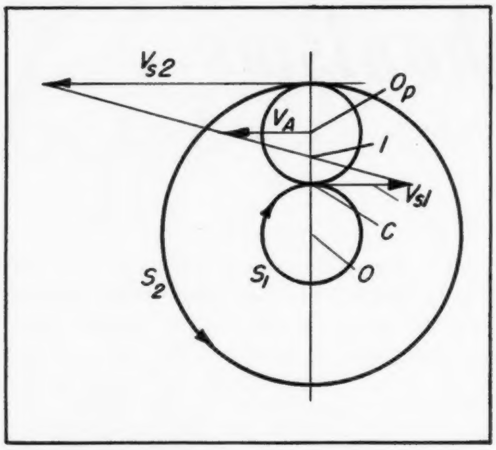


Fig. 3 — Left — When arm speed V_A is less than $V_{s2}/2$, sun gear S_1 rotates opposite to gear S_2

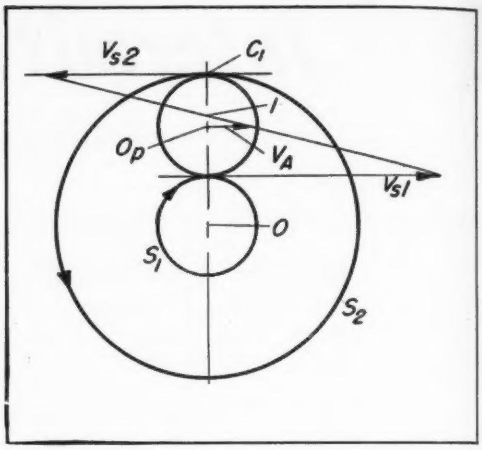


Fig. 4 — Right — Reversing direction of arm speed V_A gives sun gear S_1 increased velocity

For condition $V_A < V_{s2/2}$, instant center I lies on centerline OO_p between O_p and pitch point C. In this case, S_1 rotates in the opposite direction to internal sun gear S_2 and, from *Fig.* 3,

$$V_{s1} = 2V_A - V_{s2} \qquad (5)$$

Nomenclature

θ = angular displacement of uniformly rotating member
ω = angular velocity of uniformly rotating member, radians per sec
R_{s1} = pitch radius of output sun pinion, inches
R_{s2} = pitch radius of internal sun gear, inches
R_p = pitch radius of planet pinion, inches
R_A = distance between centers of sun and planet pinions, inches
R_o = radius of eccentricity, inches
R_F = pitch radius of cage gear, inches
V_{s1} = pitch line velocity of output sun pinion, inches
V_{s2} = pitch line velocity of internal sun gear, inches
V_A = linear velocity of center of planet pinions, inches
θ_A = angular displacement of cage or arm
ω_A = angular velocity of cage, radians per sec
α_A = angular acceleration of cage, radians per sec²
ω_{s2} = angular velocity of internal gear, radians per sec
θ_{s1} = angular displacement of output sun pinion
ω_{s1} = angular velocity of output sun pinion, radians per sec
α_{s1} = angular acceleration of output sun pinion, radians per sec²
N_B = No. of teeth in driving gear
N_D = No. of teeth in driven external gear
N_{s2} = No. of teeth in internal sun gear
N_{s1} = No. of teeth in output sun pinion
m_1 = gear ratio between driving and mating external gear $= N_B/N_D = -\omega_{s2}/\omega$
m_2 = gear ratio between internal sun gear and output sun pinion $= N_{s2}/N_{s1}$
S_R = linear displacement of rack, inches
V_R = linear velocity of rack, inches per sec
a_R = linear acceleration of rack, inches per sec²

$$\omega_{s1} = \frac{2\omega_A R_A - \omega_{s2} R_{s2}}{R_{s1}} \qquad (6)$$

For condition V_A in opposite direction to V_{s2}, *Fig.* 4, instant center I lies between O_p and pitch point C_1, then sun pinion S_1 will rotate in opposite direction to internal sun gear S_2, and

$$V_{s1} = 2V_A - V_{s2} \qquad (7)$$

$$\omega_{s1} = \frac{2\omega_A R_A - \omega_{s2} R_{s2}}{R_{s1}} \qquad (8)$$

When $\omega_A = O$, instant center I lies on O_p and

$$\omega_{s1} = \frac{V_{s2} R_{s2}}{R_{s1}} \qquad (9)$$

Thus, by changing the angular velocity of cage A, while internal sun gear S_2 rotates at a uniform angular speed, sun pinion S_1 can be made to remain at rest or to rotate at a definite angular velocity in either direction.

When the cage is given a simple harmonic motion, there results a special case in which the conditions of zero acceleration at the start of the motion of the driven sun pinion, and zero deceleration at the end of its motion, are fulfilled, provided the moving bodies are rigid.

A consideration of the foregoing conditions and of the relationships between the members of a planetary gear system led to the design of the following devices, the description and analysis of which are given in this Data Sheet and in subsequent ones to be published in succeeding issues.

A. Internal Planetary Gear System with Rack and Scotch Yoke Control Mechanism
B. Fixed Eccentric and Sliding Rack Control Mechanism
C. Simple External Planetary System and Fixed Eccentric Control Mechanism
D. Internal Planetary Gear System with Rack or Segment and Cam Control Mechanism
E. Screw and Gear with Cam Control Mechanism

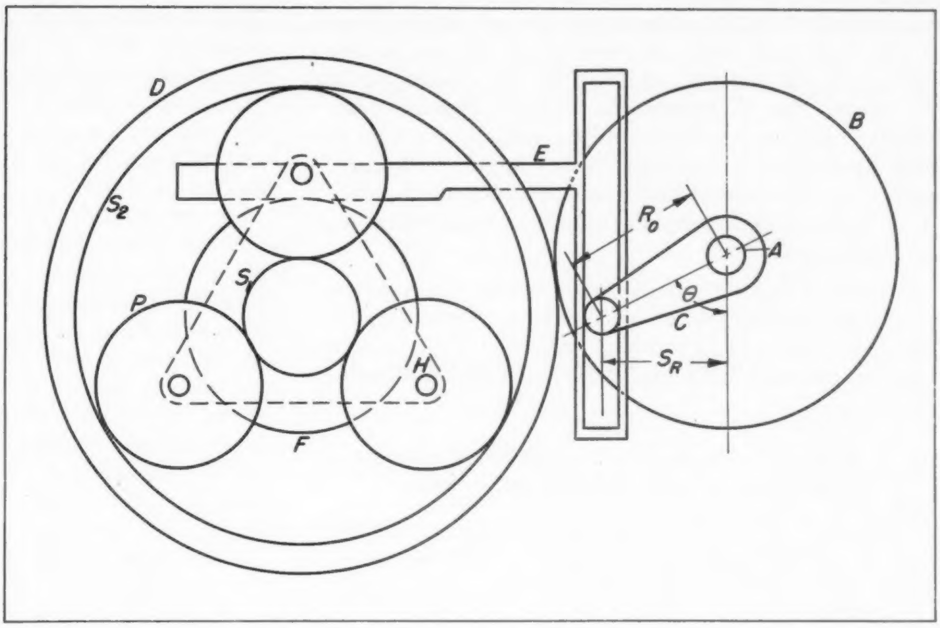
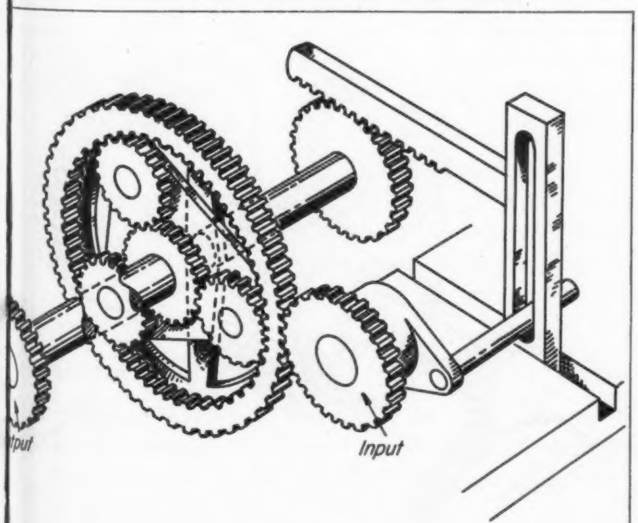


Fig. 5—Schematic diagram of internal planetary system with rack and scotch yoke control

A. Internal Planetary Gear System with Rack and Scotch Yoke Control

As shown in *Figs.* 5 and 6 the mechanism consists of a drive shaft *A*, gear *B* and crank *C*. Gear *B* meshes with gear *D*, which is integral with internal gear S_2 of a planetary gear unit, while crank *C* is part of a scotch yoke mechanism to which rack *E* is attached. Rack *E* in turn actuates gear *F* fastened to cage *G* carrying planet pinions *P* which are free to rotate on pins *H* mounted on cage *G*. Pinions *P* are in mesh with both internal sun pinion S_2 and output sun pinion S_1. In this simple planetary system the internal gear is the driving member rotating at uniform velocity, while the center of the planet pinions moves in a simple harmonic motion.

Fig. 6—Perspective view of internal planetary gear system with rack and scotch yoke control mechanism



ANALYSIS: From the geometrical conditions indicated in the figures, and using the ratios m_1 and m_2 (defined in the Nomenclature) the following relations hold true:

a. *Motion of rack*

$$S_R = -R_o \sin\theta = \frac{-m_1 m_2}{m_2+1} R_F \sin\theta$$

$$V_R = -\omega R_o \cos\theta = \frac{-m_1 m_2}{m_2+1} R_F \omega \cos\theta$$

$$a_R = \omega^2 R_o \sin\theta = \frac{m_1 m_2}{m_2+1} R_F \omega^2 \sin\theta$$

b. *Motion of cage*

$$\theta_A = \frac{-R_o \sin\theta}{R_F} = \frac{-m_1 m_2}{m_2+1} \sin\theta$$

$$\omega_A = \frac{-\omega R_o \cos\theta}{R_F} = \frac{-m_1 m_2}{m_2+1} \omega \cos\theta$$

$$\alpha_A = \frac{\omega^2 R_o \sin\theta}{R_F} = \frac{m_1 m_2}{m_2+1} \omega^2 \sin\theta$$

c. *Motion of output sun pinion*

Since sun gear S_1 rotates in the opposite direction to sun gear S_2, *Fig.* 3 and Equations 5 and 6 apply, with the following results

$$\theta_{s1} = m_1 m_2 (\theta - \sin\theta)$$

$$\omega_{s1} = m_1 m_2 \omega (1 - \cos\theta)$$

$$\alpha_{s1} = m_1 m_2 \omega^2 \sin\theta$$

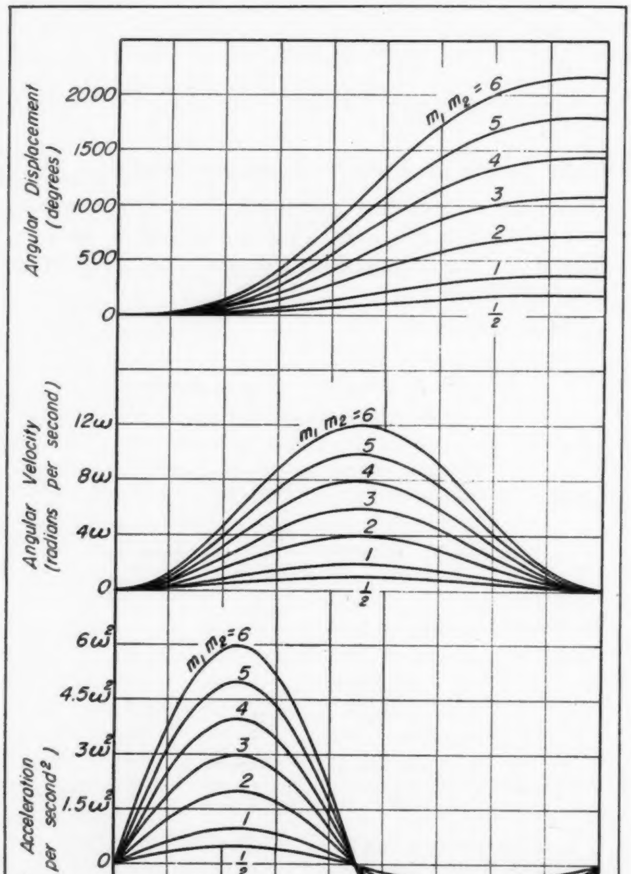
The equation of the acceleration of the output

ENGINEERING DATA SHEET

pinion indicates that the acceleration curve is a sine wave, which fulfills the conditions of zero acceleration at the start and zero deceleration at the end of the motion of the output shaft. This is illustrated in the chart, *Fig.* 7, where the angular displacement, velocity, and acceleration of the output shaft have been plotted as a function of the angular displacement of a drive shaft rotating uniformly at the rate of ω radians per second and for values of $m_1 m_2$ varying from ½ to 6.

Quadric Crank Control Mechanism: for reasons of design, construction, and compactness, also to eliminate the sliding actions inherent to a scotch yoke mechanism, it is preferable, in many instances,

Fig. 7—Motion of output sun pinion for the mechanism of Figs. 5 and 6, with different gear ratios



to replace the scotch yoke and rack mechanism by a quadric crank. In so doing, however, the motion of the cage deviates from simple harmonic, due to the effect of the angularity of the connecting link. This deviation in the motion of the cage results in a departure from the sine wave acceleration and from the symmetry of the motion of the output shaft.

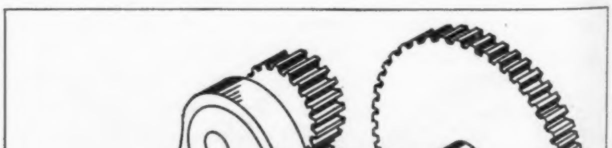
In some applications this deviation may be objectionable but, in general, the value of the acceleration and deceleration at the start and at the end of the motion of the output shaft is sufficiently small to be of no importance in practice.

When the scotch yoke and rack mechanism is replaced by a quadric crank, the analysis of the motion of the cage and of the output shaft is more complex. First of all, the equations of the motion of the driven member of a four-bar linkage, which are also those of the oscillating cage, must be introduced in the analysis. These have been published (see Mathematical Analysis of Four-Bar Linkage, Machine Design, May 1942) and can readily be applied. However, the radius of the crank must be accurately determined so that the maximum angular velocity of the driven link or cage will be made equal to $m_1 m_2 \omega/(m_2 + 1)$.

To determine this radius, it is known that it should be less than $m_1 m_2 R_{s1}/2$ and it is necessary, therefore, to use values somewhat smaller and to calculate the angular velocity of the cage until a crank radius is obtained which imparts to the cage a maximum angular velocity equal to $m_1 m_2 \omega/(m_2 + 1)$. This angular velocity should in no case be greater, otherwise the output shaft will reverse its motion; in practice it is advisable to decrease the crank radius by a few thousandths of an inch. While this procedure may appear cumbersome, the required crank radius can be determined accurately and rapidly with calculating machines. Then, knowing the radius of the crank, the equations of motion of the cage are combined with the motion of the internal sun gear of the planetary system to determine the motion of the output sun pinion.

(Continued next month)

Fig. 8—Perspective view of internal planetary gear system with quadric crank control mechanism

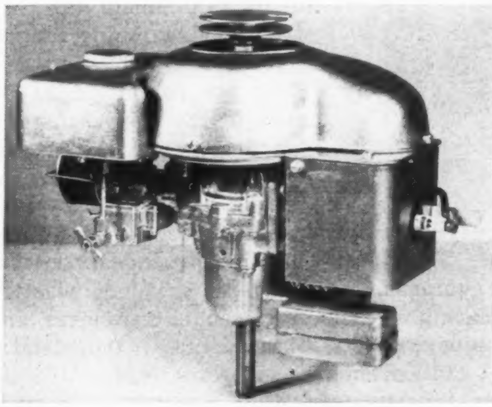


new parts and materials

For additional information on these new developments see Page 261

Vertical-Shaft Gasoline Engine

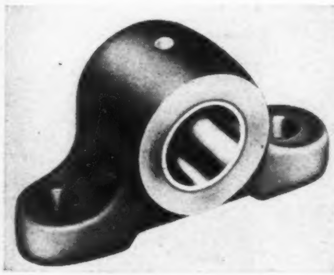
Aluminum vertical-shaft gasoline engine measures 8½ by 10½ by 14 inches and weighs 16 pounds. It develops one horsepower. The engine is of the 2-cycle type, having a built-in magneto, and will operate



tilted to 45 degrees. Recommended applications include compressors, generators, and lawnmowers and other portable machines. Manufacturer: Power Products Corp., Grafton, Wis.

For additional information circle MD 1 on page 261

Porous-Bronze Pillow Blocks



Line of porous-bronze pillow blocks have cast iron frames. Capillary structure enables the bearing to supply oil to journal as required, and oil supply is augmented by reservoir machined into the housing. Units are available for shaft diameters of ½, ⅝, ¾, ⅞, 15/16 and 1 inch. Manufacturer: Precision Products Co., 815 Pryor St., S.W., Atlanta.

For additional information circle MD 2 on page 261

Bronze Plug Valve

Aluminum-bronze plug valve is corrosion resistant and is especially designed for use on process equipment. It can be furnished with any type connection—flanged, threaded, or hose-coupling thread. Provision is made for pipe connections for meters, gages, etc., in the 2-inch size. Sizes available are ½ to 4-inch. Manufacturer: Ampco Metal Inc., 1745 S. 38th St., Milwaukee 4.

For additional information circle MD 3 on page 261

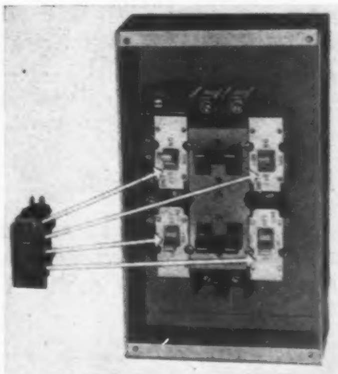
Reset General Purpose Counters

Series 1260 counters are of the reset general-purpose type and feature modern styling and ease of reading. They are designed for mechanical operation and can be actuated from either side. The dial is direct reading to six figures. Four types are available: Ratchet, rotary ratchet, direct drive, or revolution with count speed ranging from 1000 to 5000

per minute depending on the style. Overall dimensions of the unit are 4½ inches long, 1 9/16 inches high and 1¼ inches wide; figures are 0.188-inch high. Manufacturer: Veeder-Root Inc., Hartford 2, Conn.

For additional information circle MD 4 on page 261

Multiple Circuit Breaker



New type Multi-Breaker electric service and load center permits circuits to be added or changed to satisfy new requirements and provides high-speed thermal magnetic switching. This type MB4 unit consists of a four-pole basic unit with provisions to receive four or more single-pole "Ad-on" plug-in units. Many circuit combinations can be made using the 33 basic stock units and the three "Ad-on" unit types. Components are

plugged in on main terminals, eliminating wiring and wiring accessories. Single pole switches for use with the assembly are rated 15, 20 and 30 amperes, while double-pole 40 and 50 ampere circuits have individual trip. Manufacturer: Square D Co., 6060 Rivard St., Detroit 11.

For additional information circle MD 5 on page 261

High-Strength Double-Hex Nut

Particularly suitable for use with NAS aircraft bolts, the Esna type EB double-hex nut has a minimum strength rating of 185,000 psi. The new fastening is interchangeable with standard internal wrenching nuts but has achieved a weight reduction of 66 per cent and a height reduction of 50 per cent. Body of the nut is cadmium-plated forged steel, while the locking element is Nylon. It is self locking in any position on the bolt. Sizes available are ¼ through 1⅛ inch in the National Fine series. Manufacturer: Elastic Stop Nut Corp. of America, Vauxhall Rd., Union, N. J.

For additional information circle MD 6 on page 261

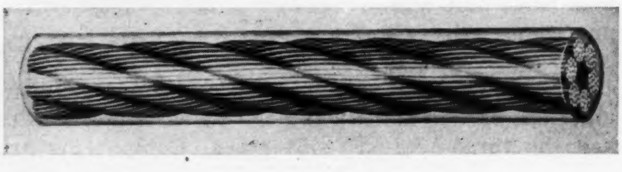
Magnetic Separator Pulley

Nonelectric magnetic separator pulley known as the Puri-Pulley is recommended for use in separating fine magnetic particles from powders ranging in size from 10 to 200 mesh. Magnetic strength of the pulley is concentrated close to the surface, this strength being about three times that of standard designs. Effective surface has also been increased by narrowing air gaps and increasing the number of pole plates. Designed for use as a head pulley in belt conveyors, the unit is available in 18 and 24 inch diameters for belt widths ranging 12 to 60 inches. Manufacturer: Eriez Mfg. Co., 574 Commerce Bldg., Erie, Pa.

For additional information circle MD 7 on page 261

Nylon-Covered Cable

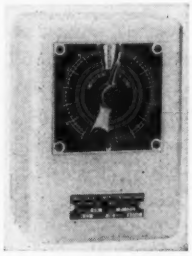
Nylon-covered wire rope is fatigue and corrosion resisting and is recommended for such applications as aircraft control cables, brake cables, textile ma-



chinery cables, etc. It is made in diameters from 1/32-inch upward. Three types are available. The first consists of single wire strands covered with Nylon. The second is more flexible and is made by extruding the plastic around formed wire rope. The third type, designed for maximum flexibility, consists of individual Nylon-covered strands formed into cable. Manufacturer: Rochester Ropes Inc., Culpeper, Va.

For additional information circle MD 8 on page 261

Instantaneous Reset Timer

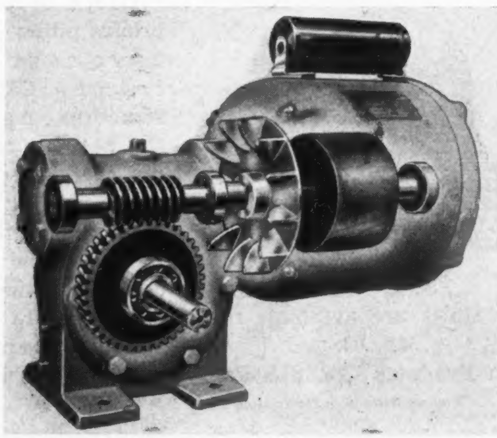


Series PAC synchronous motor driven timers are made in styles having timing ranges from 5 frequency cycles to 3 hours. They are calibrated in 5 cycle steps in the first instance and 2 minute steps in the second. The units are designed for process control where long life and trouble free operation are required. The timers are recommended for use with such equipment as automatic grinders, plastic molding machines, packaging machines, welders, and photographic printers. Manufacturer: Industrial Timer Corp., 115 Edison Place, Newark, N. J.

For additional information circle MD 9 on page 261

Low-Speed Gearmotor

Speeds as low as 9 rpm can be achieved by new gearmotor made in models having reductions up to 96:1. Sturdily made, parts are supported on a heavy frame with four mounting holes and torque strains are directly absorbed by the main frame of the as-

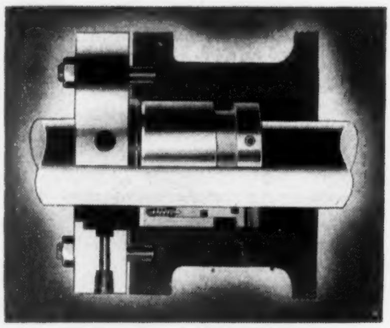


sembly. Lubrication is by the splash system, the bronze worm wheel and steel worm being constantly bathed in a flow of oil. Sizes from ⅛ to 1½ hp and speeds from 9 to 3600 rpm are available. Both single and polyphase 50 and 60 cycle motors can be specified. Standard motor speeds include 900,

1200, 1800 and 3600 rpm using semi or totally enclosed types. Manufacturer: United Electric Machinery Co., 1824 N. 72nd Court, Elmwood Park 35, Ill.

For additional information circle MD 10 on page 261

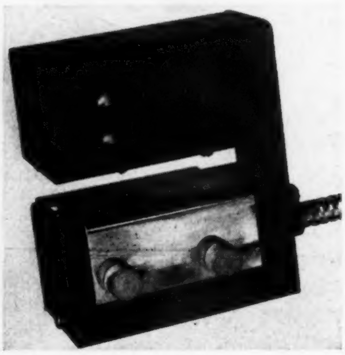
Nonlubricated Rotary Seal



For use with light hydrocarbons at pressures up to 600 psi, Type P.S. seal rotates with the shaft, produces no wear on shaft or sleeve and requires no lubrication. The seal has no special sleeves or modification of shaft except drilling of small hole for locking set screws. Applicable at temperatures up to 250 F it is particularly suitable for use with gases such as propane and butane where the seal must operate dry. Manufacturer: Durametallic Corp., 2104 Factory St., Kalamazoo 24F, Mich.

For additional information circle MD 11 on page 261

Photoelectric Edge-Guide Scanner



Used in process machines to initiate a signal when the edge of a sheet or strip moves from an established center line, the type SC 311 scanner will indicate the direction of the movement and actuate control devices. Two adjustable position slots in the bed of the device are aligned with phototubes. Since the normal condition is when only one slot is covered, covering of both slots indicates a motion in one direction, while uncovering of both slots indicates a motion in the opposite direction. By appropriate wiring, controls will serve to actuate positioning devices, cut-offs, etc. Manufacturer: Langevin Mfg. Corp., 37 W. 65th St., New York 23.

For additional information circle MD 12 on page 261

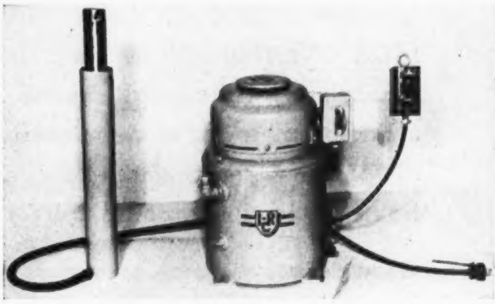
Corrosion-Resisting Coating

Thermoplastic coating material known as Enthonite 101 is highly resistant to all types of inorganic solutions. It is particularly recommended for use in protecting surfaces against the attack of hydrochloric, nitric, hydrofluoric and other strong acids. The plastic is applied as a viscous fluid containing no solvents. It can be brushed, dipped or sprayed as coatings from 1/8 to 1/4-inch thick. Curing is achieved by baking at 350 F for a short time. If patching is necessary, it can be done in place using an infrared lamp for the cure. Manufacturer: Enthone Inc., 442 Elm St., Dept. MD, New Haven 2, Conn.

For additional information circle MD 13 on page 261

Hydraulic Power Unit

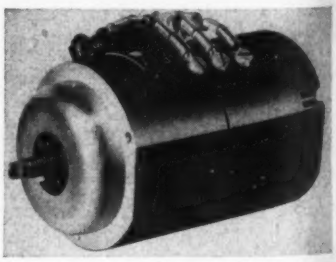
Pressure of 1000 psi and delivery of 1½ gpm is developed by a new hydraulic power unit. The power package consists of a flange-mounted motor superposed on a 2½ gallon oil reservoir. Controls are furnished; in assembling the unit all that is required



is the connection of oil and power lines. Two controls are standard, main starting switch and pushbutton operating switch. Foot switch is optional. Valves use open-center arrangements permitting the motor to idle except when unit is under load. Adjustable relief valve and electric control valves are built into the base of the unit and are readily accessible. A wide combination of motors, pumps and controls can be furnished as can various styles of hydraulic cylinders. Manufacturer: Lyon - Raymond Corp., 5854 Madison St., Greene, N. Y.

For additional information circle MD 14 on page 261

Synchronous Differential



Engine synchronizing device serves as an intermediary speed regulator. Unit consists of two synchronous motors and a mechanical differential. These motors are powered by small "tachometer" generators coupled to the engines. Each of the two synchronous motors, therefore, rotates at the operating speed of its engine. Since each motor feeds into an input of the differential, the differential output indicates by its speed one half the difference in speed of the engines; its dirction of rotation indi-

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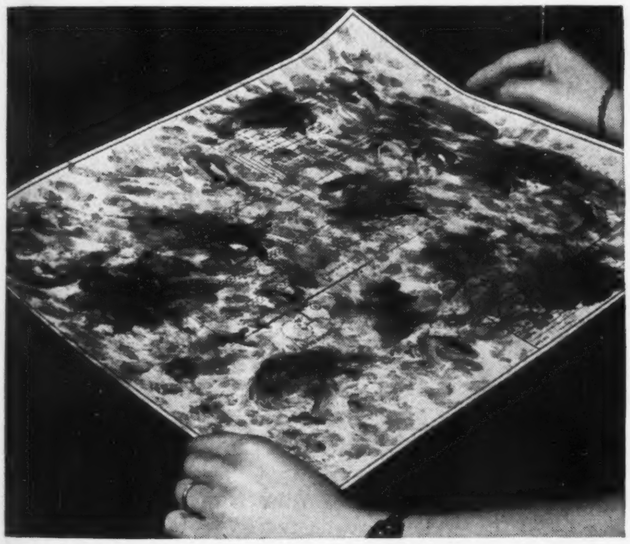

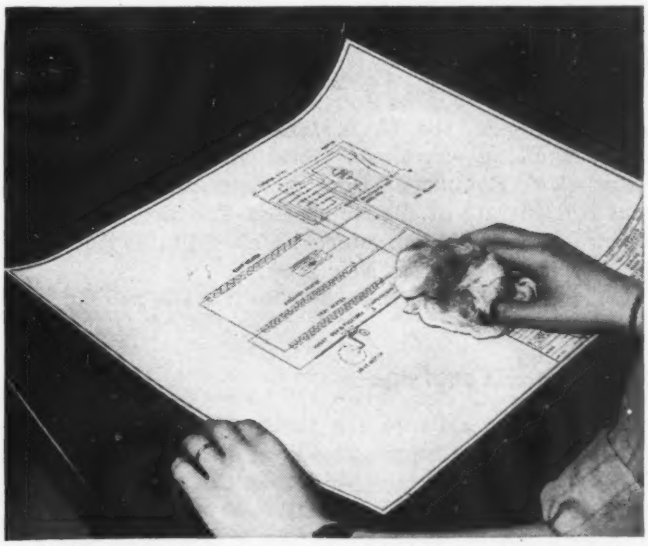

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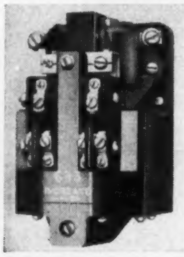
cates which engine is operating faster. Unit measures 3 45/64-inches long and 2 ⅜ inches in diameter. It weighs 28 ounces. Presently available differentials operate from a three-phase source over a frequency range of 15 to 60 cycles at an input voltage 0.007 times the frequency in cycles per second. Units for operation on high voltages or single and two phase are also available. Manufacturer: Kollsman Instrument Div., Square D Co., 80-08 45th Ave., Elmhurst, N. Y.

For additional information circle MD 15 on page 261

A-C Pneumatic Timer



Designed for a wide variety of timing needs, new a-c pneumatic timer may be screw adjusted through the timing range 0.3-second to 3 minutes. The unit measures 2¾ inches wide, 4⅞ inches long and is adjusted from the front by means of a screw driver. Two types are available, one with one timing step, the other with two. In the second type, the two steps are independently adjustable. Manufacturer: Cutler-Hammer Inc., 328 N. 12th St., Milwaukee 1.

For additional information circle MD 16 on page 261

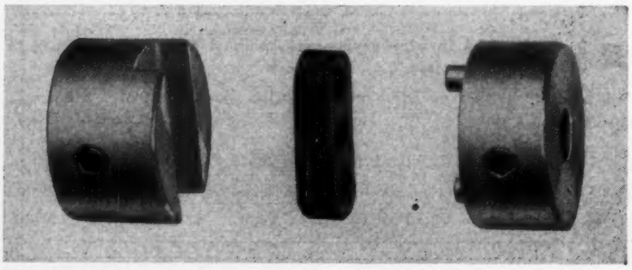
Solid Rubber Tire

Featuring soft inner construction and tough long-wearing treads, the U. S. Innacush industrial tire has cushioning effect and vibration absorbing characteristics. Equipment thus receives reduced shock and can operate at higher speeds. The tire is available in 17 sizes. Manufacturer: United States Rubber Co., Rockefeller Center, New York.

For additional information circle MD 17 on page 261

Low-Torque Couplings

Particularly suitable for instrument applications, type C-O flexible couplings will transmit 1/20 hp at 2000 rpm or 1/10 hp at 5000 rpm. Couplings consist of three parts, two die-cast bodies which engage a molded neoprene insert by means of drive pins and a slot in the driven member. Design is said to prevent extrusion of the rubber and provide shock and overload protection. Bore sizes include ⅛, 3/16, ¼, 5/16 and ⅜-inch. Major diameter of the couplings is ⅞-inch, length is 1 inch. Manufacturer: The Climax Flexible Coupling Co., 863 E. 140th St., Cleveland 10.



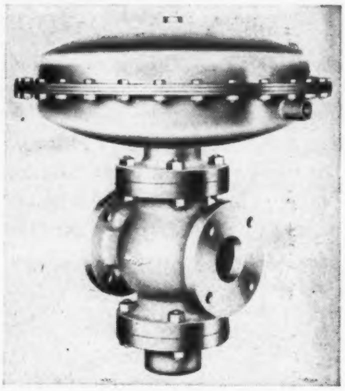
For additional information circle MD 18 on page 261

Water-Resistant Electric Wire

New type of rubber-covered electric wire has moisture resistance that improves with immersion. It is, therefore, particularly recommended for applications where moisture is prevalent or where splashing is particularly likely to occur. The material is marketed under the trade name Laytex RUW. Manufacturer: United States Rubber Co., Rockefeller Center, New York.

For additional information circle MD 19 on page 261

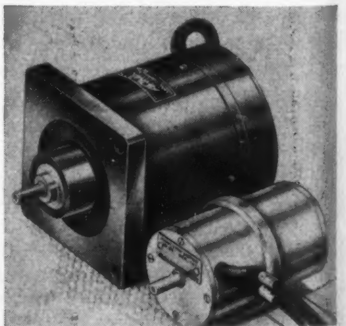
Diaphragm Control Valves



Series 4000 control valves provide high sensitivity by direct diaphragm balancing of line and fluid pressures without the use of springs. Loading pressure from an air-operated instrument is applied to the upper side of the diaphragm in the usual manner and fluid pressure from the outlet side of the valve body is applied to the under side of a larger area diaphragm. This construction eliminates packing boxes and reduces friction and hysteresis. Valve bodies are either cast iron or cast steel, diaphragm cases are of steel construction. Trim material is type 304 stainless with other materials also available. Maximum operating pressure of the valve is 250 psi. Manufacturer: Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.

For additional information circle MD 20 on page 261

Servo Induction Motors and Generators



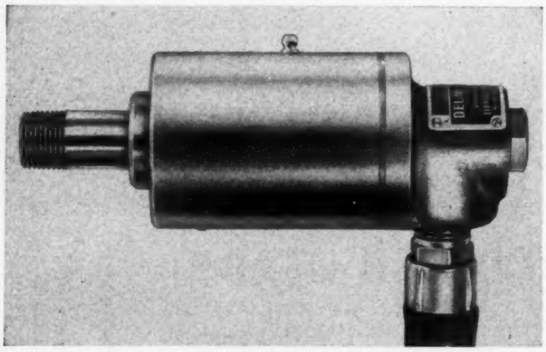
Line of induction motors and generators has been designed for high-performance servo and instrument application. The motors feature low inertia and bearing friction combined with high starting torque. They are made in three size groups for use at 60 cycles and one group for use at 400 cycles. Mountings are designed for ease in setting

up precision gear meshes, double shaft extensions are standard on all types. Stall torques range from 1.8 to 18 at 60 cycles, maximum watt output ranges from 1.5 at 1750 rpm to 18 at 2000. The induction generators are of two-piece frame construction using precision bearings. They are temperature compensated and have linear voltage speed characteristics. Five types are available to produce 90 volts, 0.15 amperes at 60 cycles. Manufacturer: Arma Corp., 251 36th St., Brooklyn 32, N. Y.

For additional information circle MD 21 on page 261

Rotating Joint

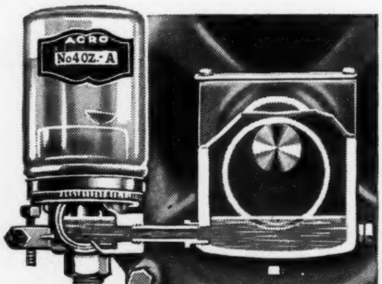
Rotating joint is made in two styles, for passage of either one or two streams of fluid. Either type, the Monoflow or the Duoflow, will handle steam, air or fluids at temperatures from −30 F to +300 F. Unit uses double-row ball bearings with lubrication provided by a purge type system, grease being held by a system of pockets. Leakage is prevented by a



pressure seal and press fit assembly. The corrosion-resisting construction materials are stainless steel, brass and cast bronze. Pipe sizes available include ½, ¾, 1 and 1½ inches. Manufacturer: Deublin Co., Northbrook, Ill.

For additional information circle MD 22 on page 261

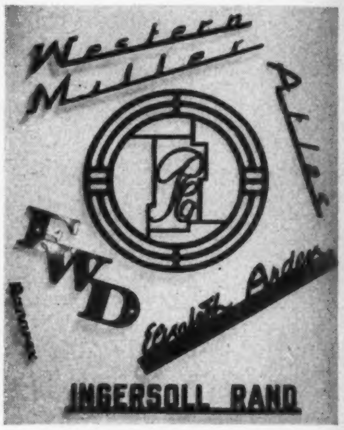
Automatic Bearing Lubricator



Automatic lubricating device provides constant-level lubrication for all types of bearings. Known as the Acro lubricator, the unit is small and compact and has no floats, valves or other moving parts. Oil level is set by means of thumb screw. Feature of the lubricator is its "dual visibility." Sight glass on the side of the bowl shows the exact level of the oil being fed to the bearing; in addition, the total oil supply remaining in the glass reservoir can be seen at a distance. Manufacturer: Acro Metal Stamping Co., 1933 N. Buffum St., Milwaukee 12.

For additional information circle MD 23 on page 261

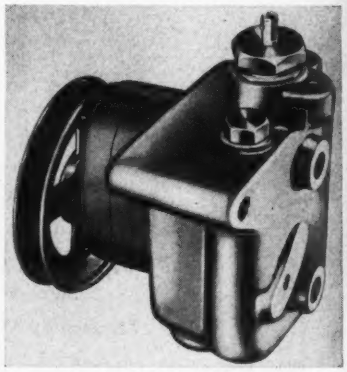
Stamped Nameplates



Diecut nameplates up to 36 inches long and ⅛-inch thick can be made at die cost of about 20 per cent of the usual rate. They are offered in stainless steel, brass, etc., and in some cases sheet plastic with letter heights up to 3 inches. Manufacturer: Dayton Rogers Mfg. Co., Minneapolis 7.

For additional information circle MD 24 on page 261

Hydraulic Power Unit



Small-size hydraulic power unit known as the Ten-Ton-Tony measures 6 by 7 by 9 inches and is rated at 1000 psi. The unit consists of a gear pump having hardened and ground gears running in bronze bearings, check valves and a four-way control valve. Capacity is 3 gpm at 1200 rpm and 1000 psi, or 4½ gpm at 1800 rpm and 1000 psi. It requires 2½ hp to operate at 1200 rpm. Manufacturer: Hydraulic Press Mfg. Co., Springfield, O.

For additional information circle MD 25 on page 261

High-Pressure Hydraulic Hose

Suitable for use in hydraulic systems experiencing sudden pressure surges, new hose is rated at 3000 psi but will withstand pressures greatly in excess of this value. Hose has reinforcement of 400,000 psi steel wire. Manufacturer: B. F. Goodrich Co., Akron, O.

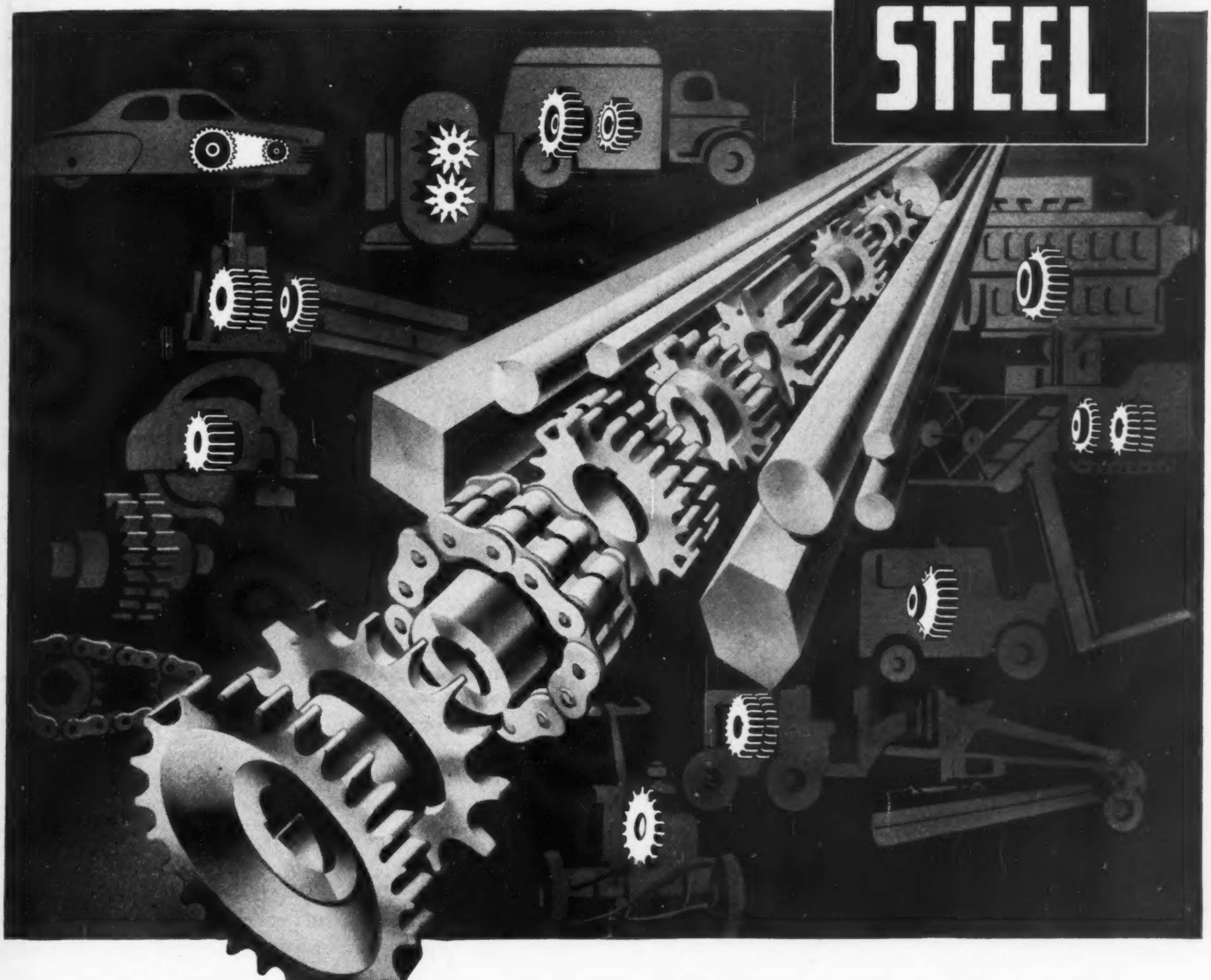
For additional information circle MD 26 on page 261

Direct-Current Generator

Direct-current generators deliver constant non-cycling current without use of rectifier, armature winding or commutator. They therefore may be operated at high speed and overload without damage.

LINK-BELT makes more and better sprockets with J&L JALCASE STEEL

J&L STEEL



More parts per hour . . . Better satisfied machine-tool operators with this original, free-machining, open-hearth steel

Link-Belt men like J&L Jalcase steel because it machines freely at high speeds, is easy to heat treat and the parts have a fine finish. They get more pieces per hour because Jalcase is uniform.

Their machinists particularly like Jalcase. They get higher production because of easier machinability, faster operation and extra long tool service.

Link-Belt is the world's largest manufacturer of conveyor and power transmission equipment—and a large producer of sprockets and chains used throughout all industry. Jalcase, because of its unique combination of free-machining and heat-treating properties, helps Link-Belt overcome the ever-increasing cost of production. This means:

- **Lower unit cost**
- **Finer finish on completed parts**
- **Higher physical properties**
- **Longer tool life**
- **Less down-time**
- **Less wear on machine tools**

We should like to tell you more about JALCASE—the *original*, open hearth, free-machining steel. The coupon below is for your convenience.

Jones & Laughlin Steel Corporation
410 Jones & Laughlin Building
Pittsburgh 30, Pennsylvania

Please send me complete data on JALCASE—the *original*, open hearth, free-machining steel.

Name ____________________
Title ____________________
Address ____________________
City ____________ State ______

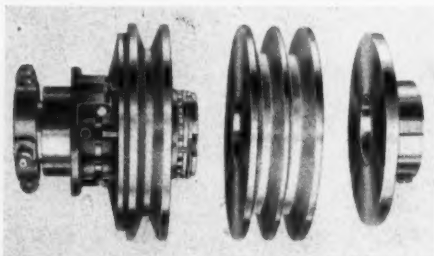
JONES & LAUGHLIN STEEL CORPORATION

Units are made in air-cooled types for use at 7.5 volts and 100 amperes as well as 15 volts and 100 amperes. Water-cooled generators will develop up to 28 volts at 400 amperes operating at 22,000 rpm. Manufacturer: Clark Electronic Laboratories, Palm Springs, Calif.

For additional information circle MD 27 on page 261

Clutch With V-Belt Pulley

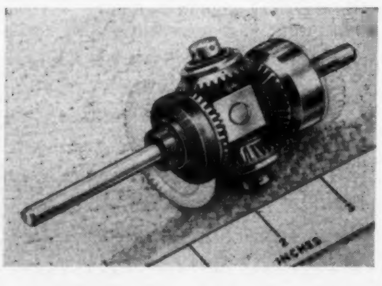
Integral clutch and V-belt pulley is said to reduce belt wear and provide easy starting and take-up for wear. The clutch is furnished in ratings of



¼ and ½ hp at 100 rpm and in shaft sizes from ¾ to 1¼ inch. It is available from stock with V-belt pulleys having one B groove with 3½, 4¼ and 5-inch pitch diameter, or with two B grooves of 4½ or 5-inch pitch diameter. Types with special pulleys or adapters are also available. Because of its compactness the clutch is especially recommnded for such applications as motor-powered lawnmowers, road markers, and other portable equipment. Manufacturer: Edgemont Machine Co., 2131 Home Ave., Dayton 1, O.

For additional information circle MD 28 on page 261

Mechanical Differentials



Line of bevel-gear differentials suitable for high-accuracy applications is made in six sizes with shaft diameter ranging from 3/16 to ⅝-inch. Work circle diameters range from 2 3/16 to 3½ inches, and length over gears ranges from 1⅛ to 2⅞ inches. Three grades of differential are made. The most accurate provides a minimum backlash of 3.5 minutes of arc, plus or minus 2 minutes of arc. The coarsest provides a maximum backlash of 24 minutes of arc plus or minus 12 minutes of arc. Manufacturer: Arma Corp., 254 36th St., Brooklyn 32, N. Y.

For additional information circle MD 29 on page 261

Bell-Switch Timer Unit

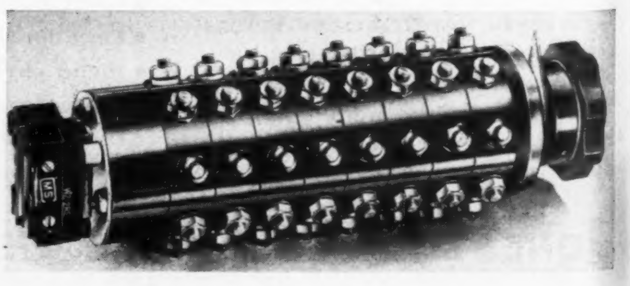
Series 5400 bell-electric switch timer unit combines a self-contained electric switch and timing unit with an alarm bell. Standard timing provided is sixty minutes and one minute intervals; however, any timer duration from 60 seconds to 12 hours can be provided. Switch is rated 20 amperes, 125 volts, 10 amperes 250 volts, and 1 hp. Timing mechanism is unaffected by variations in line current. On completion of interval, the circuit is broken and the bell rings. A hold-on feature is available to keep circuit closed until opened manually. Manufacturer: M. H. Rhodes Inc., Hartford, Conn.

For additional information circle MD 30 on page 261

Multiple-Contact Switch

Featuring the use of current interrupters which eliminate arcing during rotation, the Tesco rotary tap switch is made in models with up to 84 positions. Unit consists of multiple sections each having 7 active contact positions and one off position. As many as 12 sections may be operated in tandem. Each switch section is rated 60 amperes continuous duty with an overload capacity of 75 amperes; operated in parallel, the assembly will handle 600 amperes. Individual switch sections measure 2½ inches in diameter over the housing and 3¼ inches over the terminal studs. Length of each section is ¾-inch. They are made of impact-resistant Bakelite moldings. Manufacturer: Eastern Specialty Co., Philadelphia 40.

For additional information circle MD 31 on page 261



HY-LOAD is an outstanding member of the Hyatt Roller Bearing family. Takes on tough loads without a murmur —rough service doesn't bother it a bit.

Universally useful because HY-LOAD is made in ten types and a wide range of sizes. A high quality roller bearing for high capacity work. Separate parts are completely interchangeable; adhering to AFBMA dimensions.

HY-LOADS, for years, have demonstrated their quality and trouble-free performance in many fields—mills and factories—on farms—oil fields—railways—highways and skyways. May we help you? Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

engineering dept equipment

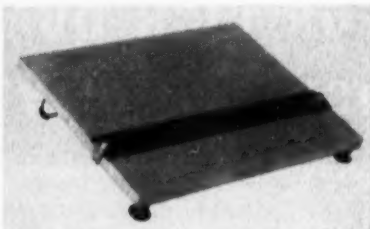
In order to obtain additional information on this new equipment see Page 261

Photocopying Machine

Feature of the Apeco Photoexact Copier is a dial-controlled filter that speeds up photocopying to 60 or more copies an hour. The unit will operate in subdued office light without use of darkroom and will reproduce photographs, drawings, blueprints, tracings, letters or printed matter. Hard plastic printing surface insures uniform contact between copy paper and original and therefore produces sharp, clear prints. Manufacturer: American Photocopy Equipment Co., 2849 N. Clark St., Chicago 14.

For additional information circle MD 32 on page 261

Handy Drafting Kit



Drafting kit available in sizes from 12 by 14 inches to 30 by 42 inches features the use of adjustment clips for aligning straight edge with board. By means of these clips, adjustment can be made with lines on the drawing, or the straight edge can be raised for use with heavy papers such as Bristol board. Straight edge can also be removed from the board easily by loosening of the clip. Manufacturer: Engineering Mfg. Co., Sheboygan, Wis.

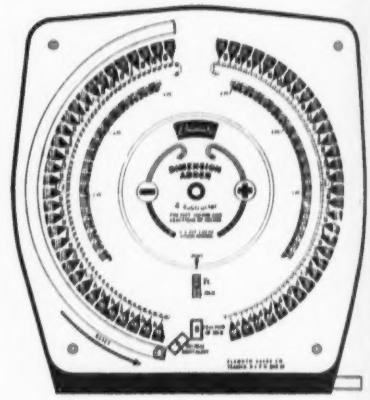
For additional information circle MD 33 on page 261

Flat-Drawer File

Drawing file has five-drawer units which may be assembled to form a file of any height. Each drawer measures 43 by 32 by 2 inches inside and has a paper depressor at the front and a protecting hood at the back to keep sheets from curling. Drawers will not pull out accidentally but may be completely removed when desired. Addition of standard interlocking cap and base to one or more file units makes a multi-section cabinet suitable for use with other office equipment. Manufacturer: Stacor Equipment Corp., 1887 Atlantic Ave., Brooklyn 33, N. Y.

For additional information circle MD 34 on page 261

Dimension Adder and Subtracter

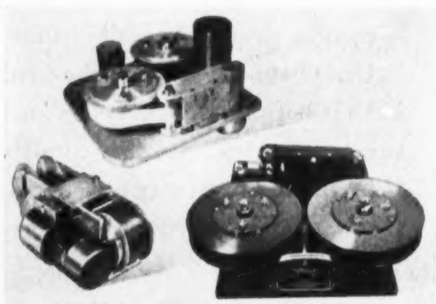


Dimensions involving feet, inches and fractions of inches can be added or subtracted, or mixed addition or subtraction can be performed on the Elemoto dimension adder. Calculations are made by manipulation of sliding elements within the computor using a metal pointer. Results, read in a window, are said to be accurate and time saving. Rotating parts and top of instrument are Vinylite, base is molded Bakelite. Manufacturer: Elemoto Sales Co., P. O. Box 62, Teaneck, N. J.

For additional information circle MD 35 on page 261

Magnetic-Tape Data Recorders

Line of compact data recorders are designed for building into all types of mobile equipment. Devices use magnetic tape to store data under conditions of

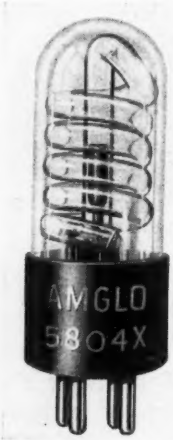


severe shock, for later re-running and analysis. All designs have multiple information channels, and, in addition, include a time base channel for speed and

error compensation purposes. Type MR-2 is a 12 channel magnetic recorder having a recording time of 15 minutes. It is applicable to recording of such data as temperatures, accelerations, strains, etc. Type MR-3 is a 6-channel recorder with a recording time of 3 minutes. Measuring 6½ by 3⅛ by 2¼ inches, and weighing 24 ounces, it is particularly suitable for applications where space and weight are critical. Type MR-6 is a standard 6-channel recorder useful where normal size and weight are permitted. Its recording time is 25 minutes. Manufacturer: Cook Research Laboratories, 1457 Diversey Parkway, Chicago 14.

For additional information circle MD 36 on page 261

High-Speed Flash Lamp

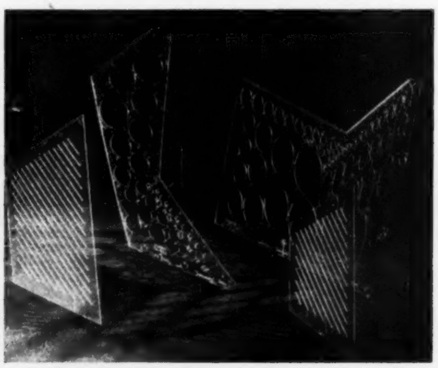


Flash lamp for use with portable photographic equipment is rated at 100 watt-seconds and 40-million lumens, and has a 1/10,000-second flash speed. The lamp, identified as No. 5804X, is flashed by means of a relay connected in series and does not require auxiliary high voltage pulse to initiate ionization. It can be used for high-speed work using either black and white or color film and can readily and permanently be syncronized leaving cable free from high voltage except for the 1/10,000-second flash pulse. Lamp measures 3½ inches in length and 1¼ inches in diameter. Manufacturer: Amglo Corp., 4234 Lincoln Ave., Chicago 18.

For additional information circle MD 37 on page 261

Drafting Stencils

Providing a quick method of preparing three-dimensional drawings of complicated objects, series of new drafting aids includes isometric and dimetric

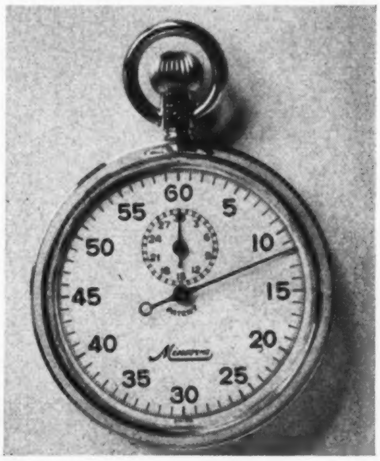


stencils. Improved features include the use of protrusions on both sides, so that the stencils "float" above surface of drawings and do not tend to smudge or smear ink. Made of Vinylite, they have excellent dimensional stability, insuring accuracy despite humidity changes. Manufacturer: Charvoz-Roos Corp., 101 Fifth Ave., New York 1.

For additinoal information icrcle MD 38 on page 261

Precision Stop Watches

Line of precision stop watches features the use of nonbreakable coil-spring mechanism said to be practically break and wearproof. Of Swiss manufacture, the watches are made in several types of pocket and



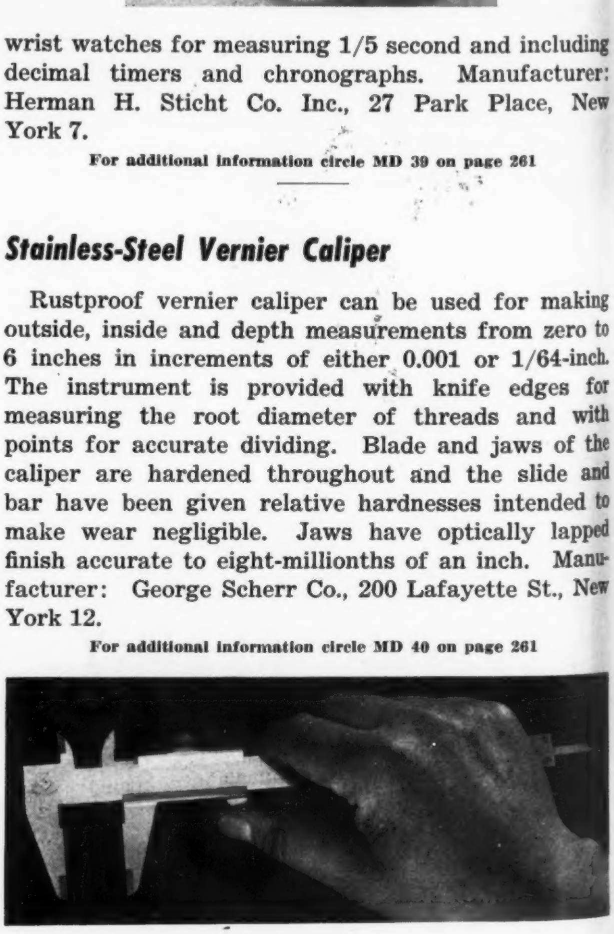
wrist watches for measuring 1/5 second and including decimal timers and chronographs. Manufacturer: Herman H. Sticht Co. Inc., 27 Park Place, New York 7.

For additional information circle MD 39 on page 261

Stainless-Steel Vernier Caliper

Rustproof vernier caliper can be used for making outside, inside and depth measurements from zero to 6 inches in increments of either 0.001 or 1/64-inch. The instrument is provided with knife edges for measuring the root diameter of threads and with points for accurate dividing. Blade and jaws of the caliper are hardened throughout and the slide and bar have been given relative hardnesses intended to make wear negligible. Jaws have optically lapped finish accurate to eight-millionths of an inch. Manufacturer: George Scherr Co., 200 Lafayette St., New York 12.

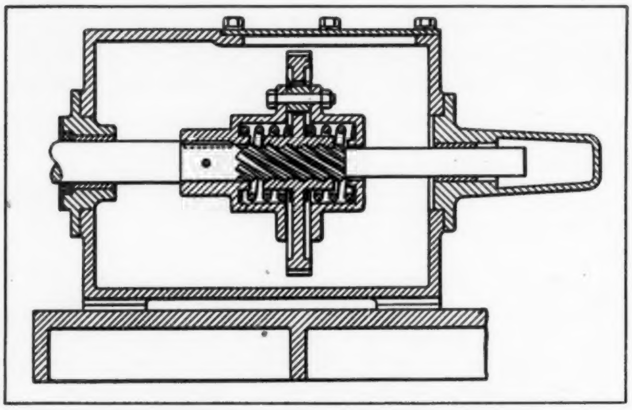
For additional information circle MD 40 on page 261



Noteworthy Patents

SELF-GENERATED fluid pressure is used for effecting shift of the tool from idle to working position or vice versa in a boring spindle covered in patent 2,438,741. Assigned to Ex-Cell-O Corp. by Walter Coulson, the spindle is entirely self-contained. Drawbar of the spindle is drawn back to shift the cutting tool into boring position by centrifugal force developed by the fluid contained in the actuator mechanism when the spindle is brought up to proper speed. When the spindle is stopped, the cutter point is automatically retracted by spring pressure to allow removal of the quill from the bored hole without marring the finish.

RESILIENT MOUNTING for gear drives to absorb the effects of sudden shock is covered in patent 2,436,798. Assigned to Westinghouse Electric Corp. by James Dunlop, the mounting is designed for applications requiring a geared connection between a power shaft and a driven shaft and will permit limited and restrained rotation of either shaft with reference to the other. Being mounted on its shaft by means of a free-running, fast-lead thread, the gear wheel absorbs the energy of sudden stops through axial action against compression springs. The gear is designed as part of a hydraulic hoisting drive and a variety of arrangements are outlined.



NECESSITY for either lubrication or bearings is obviated by utilizing the repelling action of like magnetic poles to center and carry the weight of a unique motor rotor. Disclosed in patent 2,436,939, the principle is applied to the motor and circulator units of three-fluid absorption refrigerating apparatus. Alnico permanent-magnet pole pieces used are designed to have angular upper faces, the angle of which is chosen so that the vertical component of the repelling force will just carry the weight of the rotor and support it at the desired clearance. Drive for such a rotor can be direct or indirect. On indirect applications the rotor is not only supported magnetically but also driven by means of an external magnetic driver and can be utilized to effect circulation of a medium within a hermetically sealed housing. Patent is assigned to the Hoover Company by Howard L. Schug.

STABILITY and ruggedness together with good sensitivity and accuracy are obtained with the load weighing device covered in patent 2,439,146 assigned to The Baldwin Locomotive Works by Arthur C. Ruge. Extremely simple and economical, the device consists primarily of three inclined, equally spaced columns welded to a base plate at the bottom and a load plate at the top. Electrical impedance strain gages of the bonded wire type on opposite sides of each of the columns register through a conventional bridge circuit the true axial component of any applied load. Tension or compression loads may be measured accurately regardless of substantial angular, torsional or eccentric loading effects created by the conditions under which the device is used.

A FLEXIBLE GEAR covered in patent 2,439,919 is designed to offer torsional flexibility and self-alignment characteristics. Assigned to Westinghouse Electric Corp. by Winston A. Brecht, the gear design is particularly applicable to drives for turbine locomotives where two or more axles are interconnected through the driving mechanism and provision is necessary to compensate for slight variations in wheel diameters and axle misalignments. The hub portion and rim of the gear are provided with spherical engaging surfaces which permit universal movement of the hub relative to the toothed rim. Torsional flexibility is obtained by providing a series of equally spaced springs disposed between seats which are engaged by lugs on the gear hub and ears on the side plates of the gear rim.

SAVE LABOR, TIME AND TUBING WITH

Uniflare TUBE FITTINGS – –

A PRODUCT OF SCOVILL

1 Self-Flaring

2 Only two parts

3 Simple to apply

4 Won't crack tubing in flaring

5 Underwriters' approved for vibration resistance

6 Flow-hole restriction within SAE tolerances

7 Retains initial tight seal even after repeated reassembly

Design engineers and production men *alike* are sold on this new UNIFLARE Tube Fitting, designed, engineered and produced in accordance with the high quality standards of Scovill Manufacturing Company. The *simplicity* of it—self-flaring . . . only two parts—spell speed and ease of assembly, time and materials saved.

Design engineers like UNIFLARE's tight seal (the tube itself will burst, *but not at the joint*, before the fitting leaks) . . . the fact that the tubing will not crack in flaring . . . that no special skill or flaring tools are required for assembly.

Production men are impressed with the number of operations this self-flaring fitting *eliminates* . . . the lighter weight and less costly tubing that can be used . . . the fact that replacement requirements can be met through regular distributors.

SEND FOR SAMPLE FITTING

If you are concerned with the specification or purchase of fittings for gas, air, oil, water or hydraulic lines, we invite you to write on company letterhead for a working sample of Scovill's UNIFLARE Fitting which will be delivered to you by a Scovill Sales Engineer. See if you don't agree that here is the simplest, cost-cutting self-flaring tube fitting you've ever seen. Address Screw Machine Products Division, SCOVILL MANUFACTURING COMPANY, Waterbury 91, Conn.

A PRODUCT OF

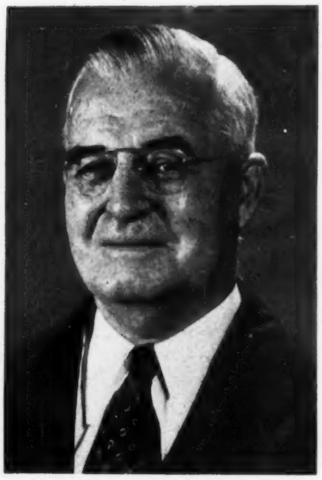
SCOVILL

SCOVILL

Uniflare The Complete, Self-flaring Tube Fitting

MEN... of ...machines

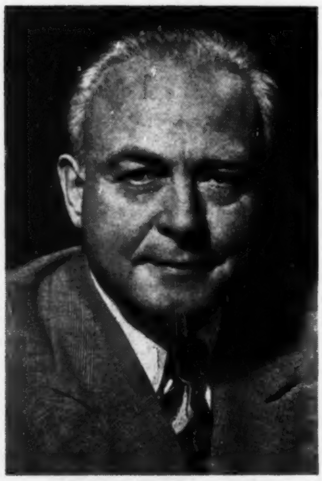
MYRON S. CURTIS has been appointed director of engineering for the Warner & Swasey Co., Cleveland, succeeding WILLIAM J. BURGER who retired June 30. Mr. Curtis joined the company's engineering staff in 1940 and was advanced to assistant director of engineering in 1945. As one of the members of the planning committee named in 1943 to guide the company's investigation and development of new products, he has been largely responsible for the development of the Warner & Swasey Sulzer weaving machine. Mr. Curtis is a native of Massachusetts and is a mechanical engineering graduate of Brown University. He resigned in 1939 as vice president and director of the Potter & Johnston Machine Co., Pawtucket, R. I., after 25 years' association with that organization, to head the shell lathe development project which was undertaken jointly by the National Machine Tool Builders Association and the Army ordnance department.



Myron S. Curtis

Richard L. Templin

RICHARD L. TEMPLIN, assistant director of research and chief engineer of tests for the Aluminum Co. of America, New Kensington, Pa., has been elected president of the American Society for Testing Materials for 1948-49. Mr. Templin has been an active member of the organization since 1917, serving as a member of its board of directors from 1936 to 1939 and as vice president in 1946. He has been particularly active in the work of the technical committees on die casting metals and alloys, light metals and alloys and in work on methods of testing. A graduate of the University of Illinois in 1917, Mr. Templin was associated with the National Bureau of Standards the following two years, and in 1919 joined the staff of the Aluminum Co. of America as chief engineer of tests. He was named assistant director of research in 1942. During his long association with the Aluminum company, Mr. Templin has been personally responsible for the development of many testing methods and has conceived and designed much of the physical testing equipment used in Alcoa's numerous testing laboratories. He has been honored by several organizations for his developments.



J. H. Kindelberger

J. L. Atwood

J. H. KINDELBERGER has been advanced to the chief executive office of North American Aviation Inc., Los Angeles,

Whistling good idea for saving gas

Fill 'er up! And don't worry about a gas overflow with its fire hazard and waste. Not on this car!

For a keen-thinking chap took a piece of tubing and designed a whistling gas-tank signal for automobiles that warns the attendant the tank is getting full. And his product is sweeping the market.

The tubing used is furnished by Bundy.

The idea was like any you could have. For you'd be amazed at where you can use Bundy tubing to put a business in the clover.

Look at the examples at the right. Some show present uses for Bundy. Others show altogether *new* ones which we think could pay handsome dividends to someone who would make them . . . maybe you. Better read them carefully.

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

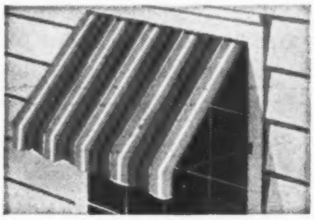
*REG. U. S. PAT. OFF.

6 What is your design or production problem . . . or even your idea? Regardless of the kind of product, Bundy engineers might easily help you over the hurdles through a simple use of Bundyweld along the line . . . and give you a stronger, better unit made faster at less cost. It's worth investigating. Just call or write *Bundy Tubing Company, Detroit 14, Michigan.*

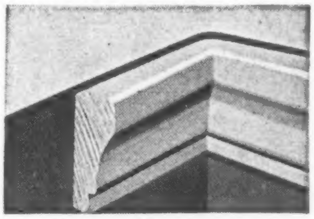
1 Automotive Engineers needed a strong, vibration-proof tubing for hydraulic brake lines. Someone said, "Let's try Bundyweld* . . . it's double-walled from a single strip." Now Bundy's in 95% of all cars!

2 Manufacturers of water coolers snapped up Bundy steel tubing, too, for condensers and other vital tubing parts. It's fast-cooling, easily fabricated. (Beer coils, too, are made of Bundyweld . . . in nickel, for purity!)

3 Bundy's in ball-point pens, too. Cartridges of Bundy Tubing hold "ink" enough for years. Tubular toys and fishing-rod tips are other unusual places where Bundy's been used to someone's profit. As for new ideas—



4 Why not use weather-resistant Bundyweld for lightweight awning frames? Bundy might well lower costs, give faster, easier installations. It's machineable, ductile, strong and readily bent to any turn.



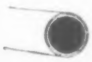
5 Automatic burglar and fire alarm systems of Bundyweld are another idea to check on. Bundy's thinner walls mean faster heat conductivity. No other tubing offers all of Bundy's features. In steel, Monel or nickel.

WHY BUNDYWELD IS BETTER TUBING

Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong, ductile tube, free from scale, held to close dimensions.



Bundyweld comes in standard sizes, up to 5/8" O.D., in steel (copper or tin coated), Monel or nickel. Special sizes can be furnished to meet your requirements.

Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, N.J.:* A. B. Murray Co., Inc., Post Office Box 476 • *Philadelphia 3, Penn.:* Rutan & Co., 404 Architects Bldg. • *San Francisco 10, Cal.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 3628 E. Marginal Way • *Toronto 5, Ont., Canada:* Alloy Metal Sales, Ltd., 881 Bay St. **Bundyweld nickel and Monel tubing is sold by International Nickel Company distributors in all principal cities.**

namely to the position of chairman of the board, succeeding HENRY M. HOGAN, resigned. At the same time J. L. ATWOOD was named the company's president.

Mr. Kindelberger has been associated with the aircraft industry since his service with the Army Air Force during World War I. Shortly after the war he became associated with the Glenn L. Martin Co., and in 1920 as assistant chief engineer, served under Donald Douglas who was chief engineer of the Martin company at that time. He continued his association with Mr. Douglas in 1925 when he became chief engineer for Douglas Aircraft Co. in Los Angeles. In that position he headed a group of nine engineers and as vice president in charge of engineering nine years later was supervising a department of more than 400 engineers. In 1934 Mr. Kindelberger became president of General Aviation Mfg. Corp., a subsidiary of North American Aviation. He was elected president and managing director of the parent organization in January, 1935 upon the dissolution of General Aviation corporation. Under his leadership North American has designed and built numerous military aircraft and is currently producing jet fighters and bombers for the Air Force as well as being active in pilotless missile research. Mr. Kindelberger is a fellow of the Institute of the Aeronautical Sciences, a member of the Society of Automotive Engineers and is chairman of the industry consulting committee of the National Advisory Committee for Aeronautics.

Mr. Atwood has been associated with North American Aviation since July, 1934, joining the organization as chief engineer and a year later becoming vice president. Mr. Atwood is a civil engineering graduate of the University of Texas and his first position was as a junior engineer with the Army Aircraft branch at Wright Field. In January, 1930 he became affiliated with Douglas Aircraft at Santa Monica, Calif. where he met Mr. Kindelberger, then chief engineer. Mr. Atwood is a fellow of the Institute of the Aeronautical Sciences and a member of the Society of Automotive Engineers.

♦

ROBERT H. AARON has been elected vice president in charge of engineering, Rhodes Lewis Co., Los Angeles, design and development engineers specializing in the aircraft field.

♦

CHARLES A. COOK resigned as assistant chief engineer of the Wisconsin Axle Div., Timken-Detroit Axle Co., to become president of the recently organized CKL Machinery Co.

♦

F. A. SCHICK, associated with Allis-Chalmers since 1935, has been appointed chief engineer of the company's Springfield, Ill., works. He succeeds A. C. BOOCK who has been named general manager of that plant's operations.

♦

JOHN F. STRICKLER recently was named assistant executive chief engineer, Bell Aircraft Corp., Buffalo. Mr. Strickler has been associated with the organization since 1936 and has been assistant chief engineer since 1946. He was graduated from Massachusetts Institute of Technology as an aeronautical engineer in 1933.

♦

HARVEY W. SMITH recently became associated with Lenkurt Electric Co., San Carlos, Calif. He is in full charge of design and construction of transformers for telephone and telegraph carrier equipment as well as for custom manufacture. Mr. Smith previously served as chief engineer of Peerless Electrical Products Co., Los Angeles.

♦

IRA H. REINDEL, executive engineer of the Norge Div., Borg-Warner Corp., is resigning from the company after an association of more than twenty years. At the time the Norge division was organized in 1927, Mr. Reindel was chief refrigeration engineer and was a key figure in the development of the company's rotary compressor. During the war he was head of a secret automatic gun director project for which he has been cited by the Navy Dept.

♦

ALEXANDER W. WUNDHEILER, who served during the war as supervisor of ordnance research, U. S. Navy Bureau of Ordnance, has been appointed research professor of mechanics at Illinois Institute of Technology, Chicago.

♦

EDWIN A. MYERS has been transferred to the mechanical development and engineering department of Dow Chemical Co., Midland, Mich., to serve as research and development engineer. EMMIT W. ARCHER has also been named a research and development engineer in the magnesium laboratory of the company.

♦

A. E. GORDON-SMITH has been appointed general superintendent of production and engineering, Silver Creek Precision Corp., Silver Creek, N. Y. Mr. Gordon-Smith had been identified for seventeen years with the E. W. Bliss Co. and is the inventor of the superspeed press.

♦

RALPH F. KOENEMAN has been appointed assistant chief engineer of the passenger car engineering division, American Car & Foundry Co., Berwick, Pa.

♦

ROSS C. CORNISH, general consulting engineer, has joined the staff of Gas Machinery Co., Cleveland.

♦

JOHN C. MCPHERSON recently was elected a vice president of International Business Machines Corp., New York. He has been associated with the company since 1930, serving as director of engineering and since 1946 as manager of patent research and development. Mr. McPherson played an important part in the development of the IBM selective sequence electronic calculator.

♦

A. W. ROSS, formerly body engineer, has been made assistant chief engineer of the Plymouth Motor Corp.

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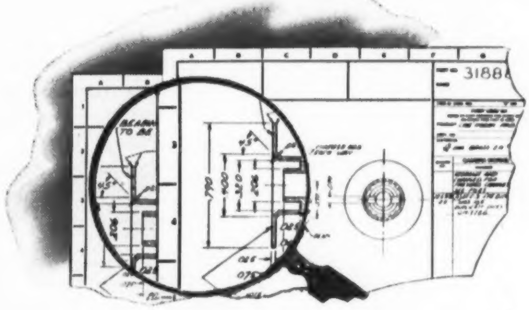

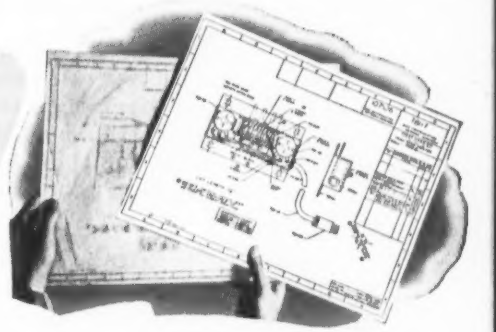

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19

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Kodak

Pressure Moldings

(*Continued from Page* 122)

signs or ornamentation on the surface affected.

STUDS: The use of cast studs which are to be subsequently threaded for attachments in assemblies should be guarded against as the threading of such studs tends to weaken the stud through the introduction of the notch-effect. The proper way to achieve the same end results is to employ bosses which may be tapped.

UNDERCUTS: Undercuts cost money because their presence generally necessitates the use of a die containing sliding members. Such a die is more costly because it is more difficult to construct. This increased construction cost is reflected in the initial die cost and usually in the price of the individual part. The latter is due to the fact that dies which have sliding members are less easy to operate than those which do not and also to the fact that, when sliding members are called for in a die, this immediately limits the total number of parts which can be put in one die and therefore the number of parts which can be cast per molding cycle. Also, the use of slides contributes to the presence of undesirable flash which must subsequently be removed by a trimming operation. This again is reflected in the piece price.

SOLID BOSSES: Solid bosses greater in diameter than ⅝-inch should not be used. The reason for this is fairly obvious: as previously mentioned, large masses of metal in a given area are to be avoided because they are susceptible to shrink porosity and because their long solidification period tends to decrease the casting cycle.

Bosses are generally used to afford a mass of metal around a drilled hole, and such holes are best cored to finish dimension thus assuring a sounder metal structure in the vicinity of the hole and also eliminating the need for drilling operations later. If the cored hole is to be tapped, at least ⅛-inch should be left at the bottom of the cored hole to facilitate chip clearance.

While one of the advantages of the pressure molding process is its ability to produce castings having cored bosses, the designer will do well to remember that projecting bosses, on surfaces which must be machined with the aid of rotary equipment such as lathes, present serious machining problems.

Coring Reduces Machining

CORING: The designer should take full advantage of the fact that pressure moldings lend themselves to extensive coring. Cores should be employed wherever possible as long as their use does not interfere with the design of the necessary die, the molding operation, or subsequent machining or finishing operations. The use of cores assures a high degree of internal soundness, makes possible more uniform wall thickness, saves metal, and reduces subsequent machining.

In taking advantage of the use of cores designers should bear in mind the following five rules:

1. Avoid extremely long cores. Cores under one-half inch in diameter should never be longer than three to four times the diameter
2. Avoid the need for interlocking cores as they cause difficulties in operating the die
3. Allow sufficient taper on all cores
4. Employ cores that form blind holes in preference to cores that form through holes because when the former are used there is no flash produced at the closed end of the hole, and a subsequent trimming operation is thereby avoided
5. Employ cores of simple shape such as regular cylindrical cores because these are the cheapest to fabricate and because they facilitate die operation.

Shown in TABLE II are recommended maximum depths for holes from 1/10 to 1-inch in diameter. Under special conditions these depths may vary to suit individual problems. In most cases it is not necessary to ream the draft from the holes. In other cases it is necessary to allow enough stock so holes can be jig reamed or bored to meet closer location tolerances than can be cast. Diameters of holes for tapping should be large enough to allow a maximum of 85 per cent of full depth of thread to provide for swelling when tapping.

TABLE II

Depth and Draft of Cored Holes

Diameter of Hole (inch)	Max. Depth of Hole (inch)	Draft on Diameter (in./in. of depth)
1/10	3/8	0.020
1/8	1/2	0.020
5/32	3/4	0.016
3/16	1 1/8	0.016
1/4	2	0.016
1/2	4	0.012
3/4	6	0.012
1	8	0.012

FLASH REMOVAL: Many designers forget that flash will always occur on a pressure molding where the die parting line intersects it and also where any moveable cores or cavity sections intersect the walls of the die cavity. While the occurrence of flash is unavoidable, the designer can often facilitate the removal of this flash by so designing the part that its flash will be accessible for easy removal by a single trimming operation. Inaccessible flash is costly to remove, viz., flash in the interior of the pressure molding.

Avoid Internal Threads

CAST THREADS: Casting external threads on pressure moldings is feasible; casting internal threads is to be avoided except in special instances. In either case, however, the decision to cast or not to cast the required threads must be made only after a cost comparison between casting them or machining them has been made. Internal threads markedly reduce casting speeds; external threads do not affect the speed. Only fairly coarse threads are readily cast and the pitch diameter should nearly approach or exceed ¾-

inch. Fine threads of small pitch diameters cannot be pressure molded.

DRAFT: A minimum of ½-inch draft is required on all outside surfaces of a pressure molding which are at right angles to the plane of die parting. In those cases where shrinkage of the pressure moldings is restricted by an internal core, ½ to 2-degree draft should be allowed to provide for rapid ejection of the pressure molding without galling or scoring. In those instances where unrestricted shrinkage is provided, relieving the outside surface of the pressure molding with only ½-degree of draft per side will facilitate easy ejection. Wherever possible as much draft as ½ to 1-degree for short dimensions and as much as 3½-degrees for long dimensions should be employed. Incidentally, sufficient draft promotes superior surface finish.

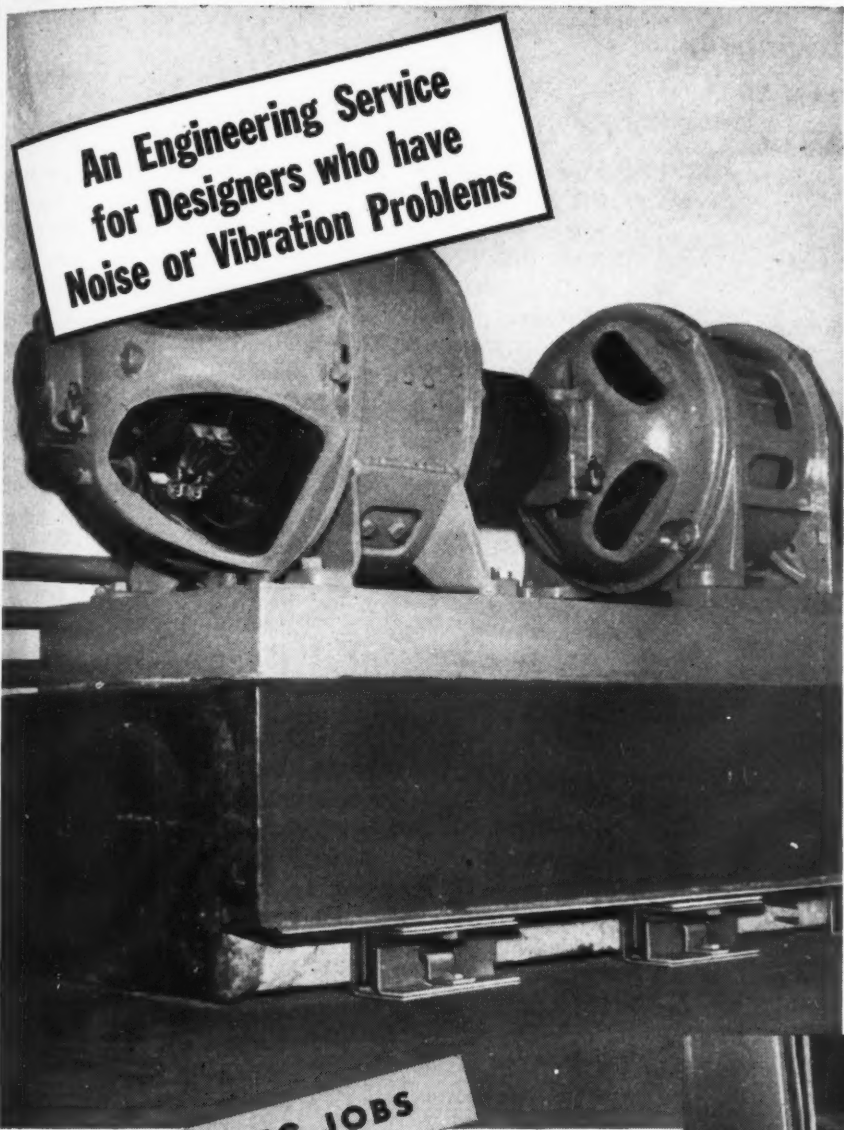
The amount of draft required on the inside surfaces of a pressure molding is largely governed by the size of the pressure molding and the extent to which the shrinkage of the metal comprising it is restricted by a portion of the die cavity. In the case of small and medium-sized pressure moldings where severe restriction of shrinkage is not affected, ½ to 1-degree of draft is sufficient. In the case of larger pressure moldings, as well as in the case of those pressure moldings where shrinkage of the metal is severely restricted, a 2-degree draft is required.

Draft Allowance for Holes

To facilitate the withdrawal of cores from pressure-molded parts, the cores must be tapered. If they are not, they will drag or hang on the cast metal and mar the inside surface of the cast holes. Cored holes must therefore be designed with an absolute minimum of 1-degree draft per side and, in the case of hubs and bosses where the shrinkage characteristic may be severe, as much as a 5-degree taper on the core pins may be required. Under no circumstances can a cored hole in the pressure molding be free of draft unless a costly collapsible core is used. If taper on the inside of cored holes interferes with the function of the part, the hole must later be drilled or reamed to the proper size. TABLE II lists the draft allowances for holes, depending on diameter and depth. For holes larger than one inch in diameter, an allowance of 0.012-inch for the first inch plus 0.002-inch for each additional inch should be made.

Draft on surfaces in square, rectangular, or irregular holes can be the same as circular holes having diameters equal to the dimensions indicating the distance between the opposite surfaces in question. Where draft is necessary on external surfaces, it should be approximately one-half the amount of draft required on inside surfaces. On surfaces against which the shrinkage takes place, the draft should be the same as on inside surfaces.

Because of the superior mechanical properties of pressure-molded parts, they are suited for many applications involving stress loading—applications precluding the use of ordinary die castings and heretofore calling for the more costly use of heat-treated aluminum alloy permanent moldings or forgings.

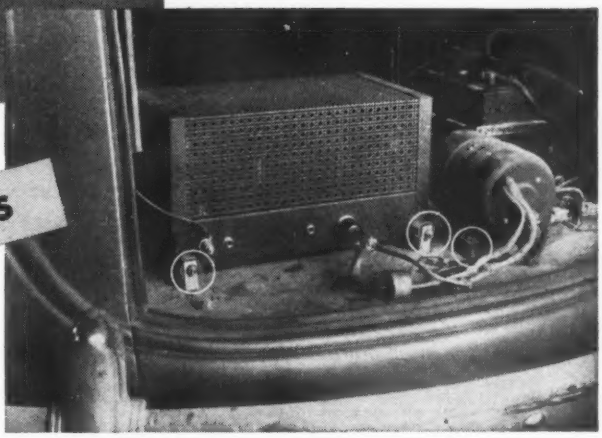


(*Left*) "We want no vibration in excess of plus or minus 1/10,000 of an inch," said officials of the Palomar Observatory of the California Institute of Technology. They referred to the motor-generator unit of the dome of the world's largest telescope. U. S. Rubber Company engineers recommended Three-Angle Type U. S. Royal Safety Mountings. These successfully met the demands of the astronomers—preventing not only the dome unit but all auxiliary power units from transmitting harmful vibration.

(*Below*) Tubes in the radio equipment of this police car were continually being broken, and there was always much unnecessary noise. "U. S." engineers recommended supporting radio, generator and battery with Cylindrical Type U. S. Royal Mountings, effectively sealing off noise and cushioning the radio against harmful vibration.

ON BIG JOBS

ON SMALL JOBS



A wide range of problems involving vibration, impact, or transmitted noise have already been solved with U. S. Engineered Rubber Mountings, by the engineering staff of United States Rubber Company. These problems involved installations—both large and small—some in the blueprint stage, others already developed. Through skill and experience, "U. S." engineers have become so successful in fighting vibration and its allied ills that it is likely they already have the answer to your particular problem, or can quickly obtain it for you. Write to U. S. Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

A PRODUCT OF

U.S. RUBBER
SERVING THROUGH SCIENCE

UNITED STATES
RUBBER COMPANY

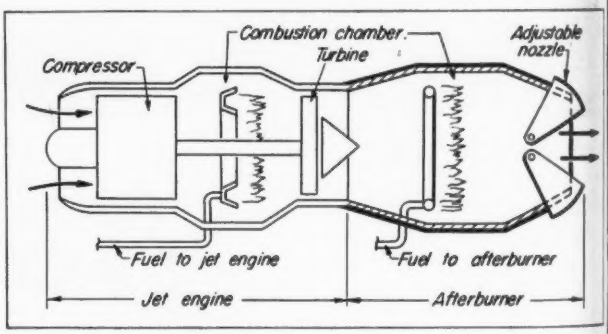
Color

(*Concluded from Page* 103)

work with capable stylists, has a good chance to outsell his less artful rivals. There are many instances where only minor changes in form and color will make the product more acceptable to its potential market. Often, firms most in need of improved appearance for their product are the last to provide their engineers with assistance in matching good performance with good looks. Many times firms who need it least are far more ready to seek and accept help. Sales are lost as often through lack of facts about the public's taste as they are through faulty judgment. The company which does not obtain the facts pays the bills, in terms of lost sales, for the firm which acts to meet demand.

Steps Up Jet Plane Speed

PRODUCTION VERSIONS of the Chance Vought XF6U-1 "Pirate" Navy fighter plane will be equipped with an "afterburner" to increase top speed of the plane under combat conditions. The afterburner utilizes the principle of the ram jet engine. Fuel is injected into the gas-flow passing through the tail pipe of the turbojet engine and is burned in the excess oxygen at extremely high temperatures. The added heat energy thus created provides extra thrust



which increases proportionately with the speed of the aircraft and is currently limited only by available materials.

Power output of a simple jet is limited by the amount of fuel that can be added without exceeding temperature limits of the turbine blades. Afterburning, however, takes place in the tail pipe without any moving parts. Hence, higher temperatures can be maintained. Designed and built by the Solar Aircraft Co. of San Diego, California, the afterburner for the Pirate is a cylindrical device approximately eight feet long. Installed on the exhaust nozzle of the Westinghouse turbojet engine, its advantages include light installed weight, small frontal area, and less airflow per pound of thrust. It recently was given a series of successful tests at the Naval Air Test Center, Patuxent River, Maryland.

PROFESSIONAL VIEWPOINTS

"Some care should be used"

To the Editor:

The article "Offset Pivot Reduces Sector Gear Noise", by Herbert F. Bariffi (MD, June, 1948), should prove helpful to designers who have a noise problem due to the clicking of sector gears. However, a study of the formulas indicates that some care should be used to avoid difficulty in extreme cases.

Eccentricity e should be held to a minimum to avoid the errors inherent in eccentric gears. To accomplish this the angle θ should not be less than 25 degrees because considerable offset is required to obtain any appreciable difference in backlash from the end to the center for small values of θ. A pressure angle of 20 degrees or more is recommended to obtain the desired backlash with a minimum of eccentricity. Backlash specified at the center should be the minimum practicable amount. The number of active teeth in the sector should not be less than eight to allow the change from tooth to tooth to be gradual. Ratios greater than 2 to 1 are preferred to avoid possible interference when more than two teeth are in contact.

The article gives formulas for center distance correction. However, the writer recommends that the center distance D_E be made standard, which is equal to $(n+N)/2P$, where n is the number of teeth in the pinion, N is the number of teeth in the complete circle of which the sector is a portion, and P is the diametral pitch. The sector cutting radius R will then be equal to $(N/2P)+e$. This avoids the danger of error in calculating special center distances and makes it possible to change the separation c and eccentricity e without changing the center distance.

CARL A. JOHNSON
Springfield, Mass.

To the Editor:

It is true that the eccentricity must be small, otherwise Equation 4 would not follow from Equation 3, and the pitch-line clearance at centerstroke likewise, as one stands or falls with the other.

So far as tooth pressure angle is concerned, writing

$$e = \frac{B_c}{2\,(1-\cos\theta)}\;\frac{\cos\theta}{\tan\theta}$$

indicates that, for a given backlash, required eccentricity decreases as the angle becomes larger.

As neither diametral pitch nor pitch radii are found in Equation 4 for eccentricity of pivot, the choice of these quantities must be dictated by other requirements. How few active teeth may be used the

How to Add Complete Rubber Inspection Facilities to Your Plant

[WITHOUT ONE CENT OF INVESTMENT BY YOUR COMPANY]

View at left shows several of a specially trained staff of inspectors at the Willoughby, Ohio factory of The Ohio Rubber Co. An almost infinite variety of small mechanical rubber parts are checked to customers' specifications in this department.

Another inspection department at the Willoughby, Ohio plant of The Ohio Rubber Company is shown at the right. In other inspection and testing departments (not illustrated) special equipment designed by our engineers is employed.

• If you had a complete mechanical rubber manufacturing department in your own plant, you would need various types of special testing machines and the trained services of inspectors and supervisors. All are available to you here at The Ohio Rubber Company without one cent of investment by your company. • When you refer your requirements for mechanical rubber goods to us, you start into action a complete organization of specialists in manufacturing to customers' specifications. Ask us to have our sales representative in your area explain the details of how well we are prepared to work with you and for you on every phase of mechanical rubber manufacturing.

This is the 8th of a series of messages relating to:

THE OHIO RUBBER COMPANY

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OHIO RUBBER CO

FACTORIES: WILLOUGHBY, OHIO • LONG BEACH, CALIF. • CONNEAUTVILLE, PA.
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author is unable to say, but it should be noted that fine pitch provides more teeth in mesh with less rubbing action and consequently quieter action.

Mr. Johnson's recommendation for center distance does permit flexibility in selection of c, but if there is danger of error in calculating a special center distance there is the same difficulty, if not more, in specifying a pitch radius of $(N/2P)+e$ the center of which has to be located at a distance of $(e+c)$ from the pivot.

Extreme applications require special considerations as do the practical aspects of all. For example, if an adjustable eccentric pivot is used, not only must the distance between the pinion center and eccentric hub be computed, but the effect of the lateral shift in the pivot as adjustment is made should be investigated, and means taken to minimize it. On the other hand, if the sector pivot is immovably secured, can one expect six (or more) tolerances to add up to zero?

HERBERT F. BARIFFI

BUSINESS AND SALES BRIEFS

NAME of the Hunter Pressed Steel Co., spring manufacturer of Lansdale, Pa., has recently been changed to Hunter Spring Co. New name is intended to better reflect the character of the business.

♦

Appointed Chicago representative handling worm-gear speed reducers manufactured by the De Laval Steam Turbine Co., L. D. Litsey will maintain headquarters at 6459 N. Sheridan Rd., Chicago 26. Other De Laval products will continue to be handled by the district office at Peoples Gas Building.

♦

Several new officers were recently elected by the board of directors of the St. Regis Sales Corp. They include: Arch Carswell, executive vice president; H. W. Sloan, vice president and director; John F. Gruber, vice president; and Walter M. Neill, vice president.

♦

Multimillion dollar research center has been opened at Brecksville, Ohio by the B. F. Goodrich Co. Investigations to be made at the new laboratory will cover chemicals, plastics, rubber, and the application of nuclear energy to rubber manufacture.

♦

Sales representatives have recently been appointed for Chicago and Cincinnati by the L.G.S. Spring Clutch Corp. Frank W. Yarline and Robert Dover are located at 20 N. Wacker Drive, Chicago as Frank W. Yarline and Co. In Cincinnati, W. F. Gregg Jr. and G. A. Spohn have offices at 626 Broadway.

♦

New executive and sales offices are now occupied by Hewitt-Robins Inc., rubber products manufacturer. Serving also as eastern sales offices for the Hewitt Rubber

K+E
CONTACT
PHOTACT
BLUE
TRACING CLOTH
410X 30

K+E
CONTACT
PHOTACT
ALBANIZED
TRANSPARENT PAPER
405 100
KEUFFEL & ESSER CO.
K+E
PHOTACT
DEVELOPER
5 GALLONS
K+E
PHOTACT
FIXER

and Robins Conveyor divisions of the company, they are located at 370 Lexington Ave., New York.

♦

Lloyd L. Lee, formerly vice-president in charge of sales and engineering of the Plan-O-Mill Corp. has been appointed manager of the Detroit office of Cleveland Republic Tool Corp.

♦

According to a recent announcement, William J. Thomas has been appointed general sales manager of the Babcock & Wilcox Tube Co. Mr. Thomas was formerly assistant general sales manager of the company.

♦

Succeeding W. O. Batchelder who is retiring, R. I. Parker has been elected a commercial vice president of the General Electric Co. Mr. Parker was formerly manager of the central sales district of the company's apparatus department.

♦

Name of the Consolidated Steel Corp. has been changed to Consolidated Western Steel Corp. At the same time, the status of two wholly owned subsidiaries has been changed to that of operating units. These are Western Pipe & Steel Co. of California and the Steel Tank & Pipe Co. Consolidated Steel Corp of Texas will continue to operate as a separate corporation under its own name.

♦

Formerly head of the Steel and Gray Iron Research Laboratories of Union Carbide and Carbon Co., Charles O. Burgess has been appointed technical director of Gray Iron Founder's Society, Inc. In this capacity he will initiate a long range program of technical research and product improvement in the interest of the society members and their customers.

♦

Charles F. Bannan, vice president of the Pacific Gear & Tool Works, has been elected president of the California Metal Trades Association. At the same time, Cloyd Gray, president of the W. R. Ames Co., was elected vice president of the association and Roy Tatam, general manager of the Western Piping & Engineering Co., was elected association treasurer.

♦

Number of changes have been made in the sales staff of Rockbestos Products Corp. H. B. Hammond has been relieved of his duties as New York district manager to devote himself to servicing federal agencies and private shipyards in the east. Replacing Mr. Hammond in New York is J. T. Williams of the Cleveland office. Replacing Mr. Williams, in turn, is D. S. Lee, former district manager of the Buffalo office which has been discontinued.

♦

Appointment of Harold T. Anderson as assistant to the general sales manager has been announced by Worthington Pump and Machinery Corp. Mr. Anderson is now in charge of sales production relations.

♦

According to a recent announcement, E. L. Behrends has joined the general sales department of Taylor Forge & Pipe Works. Mr. Behrends was formerly vice president of the George B. Limbert Co. and manager of the Western Supply Div. of the Lummus Co.

♦

Previously manager of distributor sales of the western district Raybestos-Manhattan Inc., A. L. Hawk has been

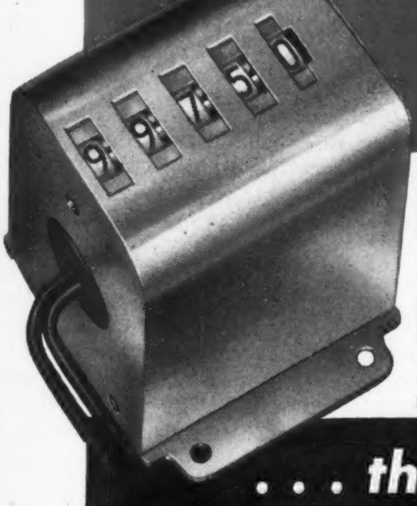
3 New

Veeder-Root

COUNTERS

Series 1260 General-Purpose Counter: Rich, modern, 2-tone gray. Veeder-Root "Ease-Eye" Reading Line of 6 bold figures. Reset. Adaptable to any standard drive, from either side.

Series 1248 Magnetic Counter: For remote indication, as from plant machines to central panel in office. 2-tone gray with "Ease-Eye" Direct Reading Line of 6 figures. Smaller size to fit more built-in installations. AC or DC. Reset.



Series 1268 Magnetic Counter: Record-breaking low cost for Veeder-Root quality. Meets the limited specifications of certain installations not requiring an extremely high number of accumulated counts, or high speeds, because of nature of the customer's equipment, like coin machines.

. . . the like of which you never saw before!

MODERN ENGINEERING IN MODERN DRESS . . . that's what you get in these new *and newsworthy* Veeder-Root Counters for electrical and mechanical operation.

Look where you will — there's nothing like these counters for streamlined design . . . smart color-contrasts . . . ease of *direct* reading . . . speed of operation . . . and, above all, *adaptability* to a wider range of products into which these counters can be built as original, integral parts.

See how easily they can be built into *your* product . . . and how powerfully they'll help build up your sales. Write.

Veeder-Root Incorporated

HARTFORD 2, CONNECTICUT

In Canada: Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3. *In England:* Veeder-Root Ltd., Dickinson Works, 20 Purley Way, Croydon, Surrey.

appointed assistant to the western district manager in Chicago. Replacing Mr. Hawk as manager of distributor sales is R. B. Hazard, formerly of the Minneapolis territory.

♦

The appointment of Bruce F. Linck as sales promotion manager was recently announced by the Elastic Stop Nut Corp. of America.

♦

A chemical division has been organized by the Goodyear Tire & Rubber Co. to handle the company's rapidly expanding manufacture and sales of synthetic rubber and chemicals. Heading up the new division is Herman R. Thies.

♦

Associated with Republic Steel Co. since 1934, Peter Robertson has been appointed assistant to the manager of the Cleveland district. For the past four years Mr. Robertson was works manager of the Truscon Steel Co., a subsidiary of Republic Steel.

♦

Number of application engineers have been added to the staff of Kennametal Inc. William L. Chambers, Kenneth Twombley and Conrad R. Seim are located in the Chicago area, working out of the office at 9 N. Jefferson St.; Gerald Transue represents Kennametal in Philadelphia and has his office at 3701 N. Broad St. while Ralph Pearce is located at the Pittsburgh office, 600 Grant St. Concurrently, Gerald Bogner and Delmar Baker have been appointed engineers and representatives. Mr. Bogner is located in the New York office at 6 W. Broadway. Mr. Baker has his headquarters at 9 N. Jefferson St., Chicago.

♦

The Holtzer-Cabot Div. of the First Industrial Corp. has been purchased by Redmond Co. Inc. The new acquisition will be known as the Holtzer-Cabot Div. of Redmond Co. Inc. and will be under the direction of Frank C. Campbell, president of the parent company.

♦

Three new field representatives have been appointed by Square D Co. With headquarters in Atlanta, S. T. Walz will manage the southeastern region; K. R. Morris will manage the eastern region with headquarters in Baltimore. From St. Louis, R. W. Thompson will direct the midwestern region which includes Kansas City, Moline and Omaha district offices.

♦

Formerly vice president of J. Walter Thompson Co., Fred C. Foy has accepted an appointment as vice president and manager of the sales department, central staff of Koppers Co. Inc. Mr. Foy was general manager of the Detroit office of the Thompson organization and was a colonel in the Army Service Forces during the war.

♦

Morton-Gregory Corp. has announced the election of L. C. Barr, M. A. Enright and W. J. Kane as vice presidents.

♦

Allis-Chalmers Mfg. Co. has announced the organization of a new mid-Atlantic region of its general machinery division's field forces. New area will embrace Philadelphia, Wilkes-Barre, Baltimore, York, Richmond and Charleston. Heading the new region, with quarters in Philadelphia, is William Arthur.

MEETINGS AND EXPOSITIONS

Sept. 27-Oct. 2—

Society of the Plastics Industry. Third National Plastics Exposition to be held at Grand Central Palace, New York City. William T. Cruse, 295 Madison Avenue, New York 17, is executive vice president.

Sept. 28-Oct. 1—

Association of Iron and Steel Engineers. Annual convention and exhibition to be held in Cleveland. Additional information may be obtained from headquarters of the society at Empire Building, Pittsburgh 22, Pa. T. J. Ess is managing director.

Oct. 3-6—

American Society of Mechanical Engineers. Petroleum committee of the Process Industries Division meeting to be held at Herring Hotel, Amarillo, Tex. C. E. Davies, 29 West 39th St., New York 18, is secretary.

Oct. 6-9—

Society of Automotive Engineers. Aeronautic Meeting and Aircraft Engineering Display to be held at Hotel Biltmore, Los Angeles, Calif. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Oct. 11-13—

American Society of Tool Engineers. Semi-annual convention will be held at the Biltmore Hotel in Los Angeles, Calif. Additional information may be obtained from Jno. M. Cannon Associates, Counsel on Industrial and Public Relations, 523 Penobscot Building, Detroit 26, Mich.

Oct. 12-16—

American Chemical Society. Fifth National Chemical Exposition and Conference to be held at the Chicago Coliseum, Chicago. Marcus W. Hinson, 1505 South Wabash Avenue, Chicago 5, is exposition manager.

Oct. 18-22—

American Institute of Electrical Engineers. Midwest General meeting to be held in Milwaukee. Additional information may be obtained from headquarters of the society at 33 West 39th St., New York 18, N. Y. H. H. Henline is secretary.

Oct. 21-22—

Society of Automotive Engineers. Production Meeting and Clinic to be held at Hotel Statler, Cleveland, Ohio. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Oct. 23-29—

American Society for Metals. Annual Convention to be held at Benjamin Franklin Hotel at Philadelphia. W. H. Eiseman, 7301 Euclid Avenue, Cleveland 3, is secretary.

Oct. 24-29—

American Welding Society. Annual meeting to be held at Bellevue-Stratford Hotel, Philadelphia. M. M. Kelly, 33 West 39th St., New York 18, is secretary.

Oct. 25-28—

American Institute of Mining and Metallurgical Engineers. Annual meeting of the Institute of Metals division to be held at Hotel Adelphia at Philadelphia. Ernest Kirkendall, 29 West 39th Street, New York 18, is division secretary.

Oct. 25-29—

National Metal Exposition to be held in Commercial Museum and Convention Halls in Philadelphia. Chester L. Wells, 7301 Euclid Avenue, Cleveland 3, is assistant managing director.

DESIGN ABSTRACTS

Design Improvement

THE technique of design improvement is one that has already come a long way. Eliminating assumptions and guess work has paid off. Making structures stronger by making them lighter was exemplified in aircraft and automotive designs and is now invading the railway field. Correcting empirical formulas from experimental studies, and reducing dependence on the "factor of safety" in design are processes as precise as they are varied.

In a few words we must try to outline a procedure for design improvement. It is this:

1. A casting, fabricated part, component or complete structure, designed analytically using overlapping assumptions, is to be improved.

2. The part is tested in service with strain gages applied so as to indicate service loads. Heretofore in most cases service loads have been guessed at.

3. A static test of the part or structure is made applying the service loads previously determined, using a testing machine, or hydraulic jacks, or other conventional loading means. This test is to determine whether all members are taking their share of the load and if not to correct them by redistributing material and stresses. It is usually more effective to reduce stress peaks by redistributing stresses without increasing weight than to "beef-up" and let the stress concentrations ride.

An accepted method of experimental stress analysis is the use of stresscoat, a brittle lacquer which provides a crack pattern under load that not only gives a qualitative overall stress picture but points out where to put wire strain gages. These latter will provide the quantitative values at points of maximum stress as needed for design improvement.

4. Having logged the stress level in a part or structure it is next in line to determine whether this level is safe or dangerous under dynamic conditions of simulated service. A life test or fatigue test of the parts or components evaluates several things:—

(a) The notch sensitivity of the material which points out the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BILL HOLLAND
3rd
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Equipped with
RZEPPA
Constant Velocity
UNIVERSAL JOINTS
In 1947, first, second and fourth cars were equipped with RZEPPA Universal Joints
All three winners—first, second and third—broke all Speedway records for the grueling 500-mile race, with average speeds only a trifle less than two miles per minute.
Rzeppa universal joints are as dependable in industry as they are in automobile and speed boat racing. Their high torque capacity, their freedom from destructive vibration and their precision manufacture make them the choice of designers and manufacturers who want the best in performance, long life and freedom from service.
Literature, describing the many sizes and types now available will be mailed on request.
The GEAR GRINDING MACHINE COMPANY
DETROIT 11, MICH., U.S.A.

safeness of the stress level in the part

(b) Shows up design flaws or stress raisers

(c) Evaluates workmanship in connections, discontinuities and surface finish conditions

(d) It furnishes a dynamic proof test, proving adequate fatigue strength for the service intended, providing a good load analysis has been made and the part is loaded as it will be in service.

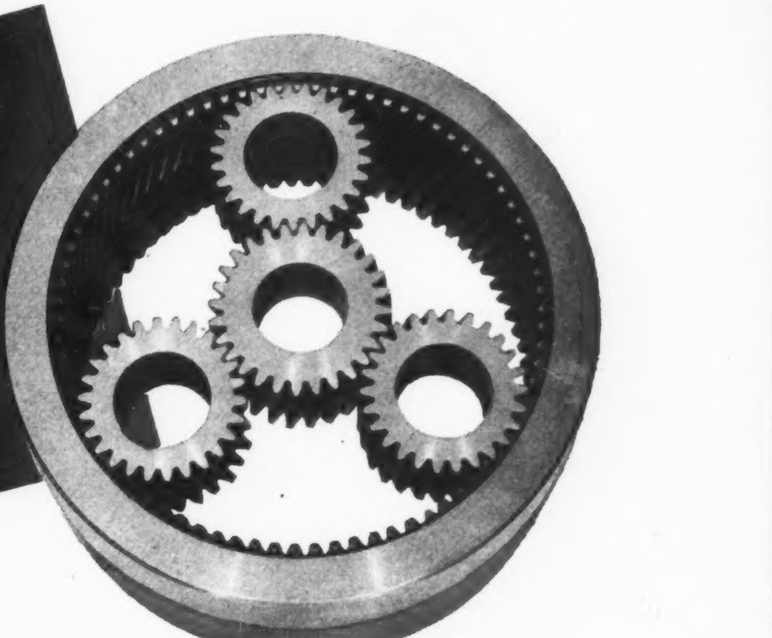
As to castings, for instance, if it is always borne in mind that stress flows in a part like fluid in a duct, a visual examination of contours will give some idea whether stress can be poured smoothly through the section or whether turbulence (stress concentrations) will exist. And while looking why not try to visualize where the neutral axes are likely to be located? They sometimes give a hint as to how to redistribute material. A casting is trying to tell you where it is in trouble, if you will give it heed.—*From a paper by F. G. Tatnall, manager of testing research, The Baldwin Locomotive Works, presented at the recent annual meeting of the American Foundrymen's Association in Philadelphia.*

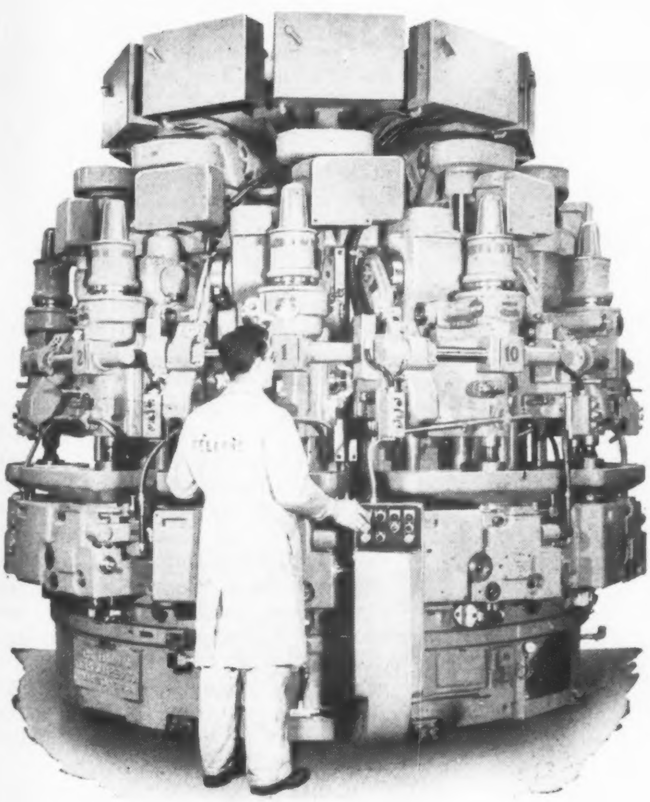
Simplicity vs. Efficiency

IN one sense, the designer views the new aircraft power plants as opening up new possibilities in the ubiquitous compromise between simplicity and efficiency. There would appear to be a fundamental relationship between engines—that the simpler or lighter the engine, the less efficient it is. The new engines have made it possible to get high output with light weight but at a cost in specific fuel consumption. Formerly we were working at essentially one point in this relationship. New developments have extended this point into a curve. This now gives the designer much more latitude and will continue to give him even more in the future. The significant thing, however, is that he cannot diminish the degree of compromise but can only shift the emphasis. It seems that only time and hard work permit simultaneous improvements in specific fuel consumption and specific output.

It can be seen that the designer is like the mechanic who has been accustomed to working with screw driver and a pair of pliers and finds himself supplied with a very elaborate set of tools. The new engines are

Speeding the Wider Use of *Internal* Gears





The No. 10 Rotary Gear Shaper excels on internal spur and helical gears. Ask for production time studies.

Inadequate production speeds no longer stand between the design engineer and the advantages to be gained through the broader application of internal gears. Today, the Fellows Rotary Gear Shaper sets new production standards on internal gears—both spur and helical. Heavy cuts at high speeds on this massive ten-station machine assures mass-productive accuracy on one or several types of gears. Now the designer can capitalize on the many advantages of the internal gear. Internal gears make possible greater compactness of design, and render longer service. For an interesting engineering analysis of applications, ask for "The Internal Gear" booklet.

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as useful as a new set of tools, and the designer requires experience to learn the proper places and ways to use the engines just as does the mechanic to use his tools. The good craftsman doesn't throw away his screw driver and pliers nor does he think of any one of the new wrenches as being better than any of the others. Each engine, like each tool, is the best to use for a certain job but may be useless on another job; therefore, he is prepared to use all of them and tries to become as adept as possible with each.—*From a paper by Dr. Milton U. Clauser, chief of mechanical design section, Douglas Aircraft Co. Inc., presented at the third national flight propulsion meeting of the I. Ae. S. in Cleveland.*

Marine Engine Research

As it takes some years to improve marine propulsion machinery radically, wartime progress in the fields of metallurgy, fuels and combustion could not be incorporated into wartime designs due to the stress of maximum production. With hostilities over, we have been actively engaged for the last two years in an intensive program of modern propulsion designs.

Inasmuch as the aircraft industry has even more stringent requirements than the Navy for saving weight, it is logical to examine many of their designs to see what features can be used to improve ship designs. The gas turbine field has many lessons for ship propulsion. One of the first results of these investigations has been a spur to steam development. It is logical to think that a boiler steam turbine plant could utilize higher temperature than 850 F, our wartime standard, if a gas turbine can operate at 1300 to 1500 F. The goal of our present efforts is to construct new prototype ships of better economy, less weight and higher power.

In machinery development we can usually see the end application of research more clearly than in basic research. We know that metallurgical research should permit new superheater materials to withstand high tube temperature, new piping of high strength at elevated temperature, and stronger and more efficient turbine blades. Research in heat treatment and hardening processes can open new fields of high tooth loading of gears, high capacity bearings, and lighter and stronger machinery parts of all kinds. Combustion research finds immediate application to boilers and gas turbine combusters,

should permit smaller furnace volumes, higher efficiency and less fouling of heat transfer surfaces. Heat transfer research has a most promising field for reducing overall size of boiler heating surface and gas turbine regenerators. Bearing and lubrication research holds promise in higher rotative speeds, always a source of higher power for less weight in addition to greater reliability at higher loads and temperatures. Research in fluid flow, both liquid and gaseous, is a must for all types of propellers, blowers, pumps, turbines, and piping or ducting.

The foregoing list is far from complete but it does serve to show to what extent the Navy depends on progress in nearly all branches of industrial research for improvement in designs of propulsion equipment. We have made a start with the present state of the art in these several fields to assemble new propulsion machinery plants of advanced design. They are:

1. Steam machinery for new high powered vessels which represents a saving of 25 to 50 per cent in weight for the same power
2. Gas turbine plants comparable in weight, space, and efficiency to steam for low and medium powers
3. 30 to 40 per cent lighter weight diesel plants for low powered ships.

In all these plants the improvement is partially due to advance in the properties of materials, but a very large part is due to elimination of unnecessary margins in factors of ignorance sometimes called factors of safety. The development and testing laboratories are responsible for the latter improvement while the research laboratory accounts for the former.

We all hear considerable about standardization and the blessings it brings. It must be realized that there is a limit to its application. Such a limit would be reached when standardization encroaches on progress and fosters stagnation. Fundamental standardization of screw threads, wire sizes, and the like are eminently desirable, but complete standardization of all end products should be avoided like the plague.

Progress at the moment is so rapid that specifications and other standardizing influences are becoming obsolete, but it is hoped that new modern specifications will evolve that will visualize continuous progress but retain the major advantages of standardization.—*From a paper by Captain A. G. Mumma, U.S.N., presented at a recent research conference of the Navy Industrial Association.*

NEW MACHINES

And the Companies Behind Them

Engraving

MARKING MACHINE. Automatic. Designed for fast, low-cost marking on light and medium heavy parts. Marks steel, iron, brass, aluminum, bakelite, other plastics, leather and wood. Also suitable for light forming and piercing operations. Cadillac Stamping Co., Detroit 7.

Finishing

PIVOT POLISHING MACHINE. Diameter to be polished from 0.004-0.158 in.; max length to be polished, 0.315; max length of workpiece, 5 in. Hauser Machine Tool Corp., Manhasset, N. Y.

Heat Treating

ELECTRIC BOX FURNACE. Has 300-2000 F temperature range; furnished with selective power modifier, vertical lift door, control panel and steel stand. Cooley Electric Mfg. Corp., Indianapolis 7.

Hotel

POT AND UTENSIL WASHER. Automatic. Furnished with housing, solution tank, pump, spray piping, drive motor, heaters and safety controls. Pump delivers approximately 200 gallons of hot cleaning solution per minute. Made in two sizes, occupying 12 and 16 sq ft. Metalwash Machinery Corp., Irvington, N. Y.

ROASTER-BROILER. Electric. For roasting meat and poultry on a skewer, and broiling steak, chops and fish on a special grill attachment. Rotiss-O-Mat Corp., Astoria, L. I., N. Y.

ELECTRONIC DEODORIZER. About size of kitchen clock; plugs in wall, and may be used continuously or intermittently. Standard Electrical Products Co., Chicago.

STEAM COOKER. Automatic. Cooking operations in each compartment controlled independently by electric time clocks so that steam period can be predetermined. Pressure automatically released making it unnecessary to remove food. John Van Range Co. Inc., Cincinnati.

KNIFE SHARPENER. Electric. Equipped with quickly replaceable abrasive stones. Four stones stroke both sides of blade at rate of 6000 times per minute. Machine can be preset for any of four positions. Steelsharp Mfg. Co., Racine, Wis.

Laboratory

PHOTOMICROGRAPHIC EQUIPMENT. For

visual and photographic work, transparent or opaque specimens, at high powers. Produces 5 x 7 in. negative. For high-power work there is a ribbon filament lamp and mechanical feed arc lamp; for low-power work there are two illuminating units and a combined stage and illuminating unit. Bausch & Lomb Optical Co., Rochester 2, N. Y.

Materials Handling

LIFT TRUCK. Single-stroke, handle-pumped hydraulic. Capacity, 2500 lb. Single-frame construction. Elevating mechanism enclosed. Push-button action engages lifting device; positive lock holds load in elevated position. Timken roller bearings in all four wheels. Lyon-Raymond Corp., Greene, N. Y.

HYDRAULIC ELEVATING TABLE. Telescopic cylinder raises, lowers table. Elevation range, 28 to 50 inches. Table tiltable to 45 degrees by hand-operated worm and gear segment. Standard metal casters. Capacity, 2000 lb. Two-speed hydraulic foot pump. Lyon-Raymond Corp., Greene, N. Y.

Metalworking

BENCH GRINDER. Powered by ¼-hp, ball bearing, constant-speed induction motor. Furnished with two wheels, 6 x 2 in., one coarse, one fine. Speed at 60 cycles is 3450 rpm. Stanley Electric Tools, New Britain, Conn.

TWIST-DRILL GRINDING MACHINES. In sizes suitable for sharpening drills from No. 52 to 4 in. Gallmeyer and Livingston Co., Grand Rapids, Mich.

TUBE-BENDING PRESS. Hydraulic, having bending combinations up to twelve, with adjustable bending depth and automatic reset. This feature together with choice of four bending radii gives a selection of any or all of 48 possible bending variations for forming. Press capacity, 20 tons. Elmes Engineering Works, Chicago 7.

DRILLER AND BORER. For drilling and line boring cross-shaft holes in 70 sizes and types of clutch housings. Two stations permit drilling and boring to be performed simultaneously. Spindle drive permits rpm to be changed to suit size of tools used. Snyder Tool & Engrg. Co., Detroit.

HYDRAULIC PRESS. Portable, of 200 metric ton capacity, for forcing locomotive crankpins. Watson-Stillman Co., Roselle, N. J.

DIE LIFTERS. Screw and hydraulic types. All steel. Height, min., 26

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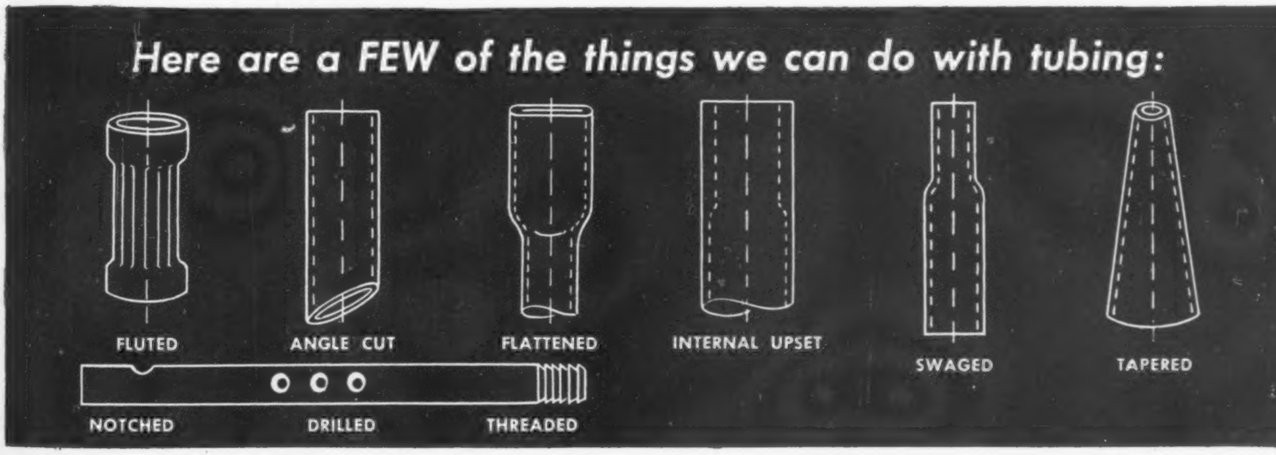

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in.; height, max., 43 in. Capacity, 2000 lb. Mounted on four casters, two swivel type and two stationary. Weights: Screw type, 290 lb; hydraulic type, 390 lb. Montgomery & Co., New York 7.

PORTABLE SHOP CRANE. Powered by double-acting hydraulic hand pump. Fabricated of formed steel; neoprene oil seals; holds load at any height; three rubber-tired roller bearing wheels. Capacity, 2000 lb; 45-inch boom; locator pin locks boom in working position. Cardinal Corp., St. Paul, Minn.

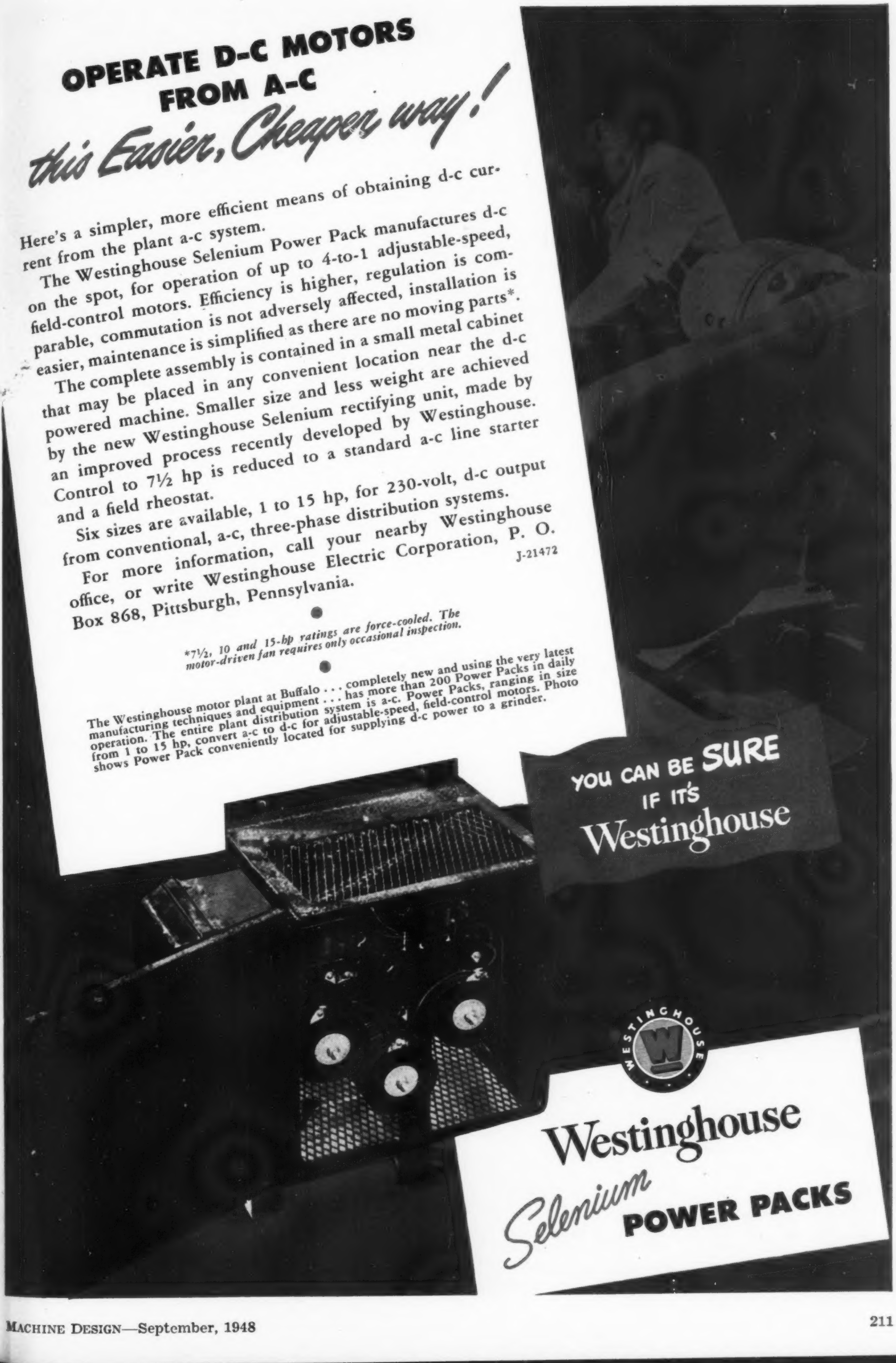
SPECIAL-PURPOSE MACHINE. Combines automatically cycled drilling, counter-drilling, chamfering, tapping and reaming operations on automotive crankshafts. Two slide units with 18-in. feed strokes move on hardened and ground ways. Tools carried in multiple-spindle heads powered by a 10-hp and a 7½-hp motor. Geneva-indexed six-station trunnion fixture mounted between heads is powered by 2-hp motor. Five stations are working positions, one is for loading and unloading. Snyder Tool & Engineering Co., Detroit.

PUNCH PRESS. Bench type; hand powered through lever and roller bearing cam. For punching, drawing, blanking, embossing, and forming. Flexible gaging arrangement provides precision location of material. Throat depth, 6¼-in.; net weight, 175 lb. O'Neil-Irwin Mfg. Co., Lake City, Minn.

FILING MACHINE. Used for filing, sawing and honing. Stepless speeds, controlled by handwheel, 170 to 470 strokes per minute. Two-power magnifier with twin lamps; universal-joint file clamp; adjustable slide bearings; air-jet chip removal. Table, 10⅜-in. square; stroke, 1½-in. DoAll Co., Des Plaines, Ill.

ABRASIVE CUTOFF MACHINE. Automatic. For high-speed cutoff of stock up to 2-in. dia. to lengths from ¼ to 12 in. Eighteen-inch cutoff wheel driven through V-belts by 10-hp motor is mounted on rocker shaft running in Timken bearings and is actuated by hydraulic cylinder. Feed mechanism is synchronized with cutting head. Bridgeport Safety Emery Wheel Co., Stratford, Conn.

DRILLING AND TAPPING MACHINE. Seven-station. Drills, countersinks and reams 10 flange holes; drills, countersinks and taps 4 bearing cap holes; drills and taps drain holes in 150 differential carriers per hour. Parts slide in and out of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Here's a simpler, more efficient means of obtaining d-c current from the plant a-c system.
The Westinghouse Selenium Power Pack manufactures d-c on the spot, for operation of up to 4-to-1 adjustable-speed, field-control motors. Efficiency is higher, regulation is comparable, commutation is not adversely affected, installation is easier, maintenance is simplified as there are no moving parts*.
The complete assembly is contained in a small metal cabinet that may be placed in any convenient location near the d-c powered machine. Smaller size and less weight are achieved by the new Westinghouse Selenium rectifying unit, made by an improved process recently developed by Westinghouse. Control to 7½ hp is reduced to a standard a-c line starter and a field rheostat.
Six sizes are available, 1 to 15 hp, for 230-volt, d-c output from conventional, a-c, three-phase distribution systems.
For more information, call your nearby Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh, Pennsylvania.
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*7½, 10 and 15-hp ratings are force-cooled. The motor-driven fan requires only occasional inspection.
The Westinghouse motor plant at Buffalo . . . completely new and using the very latest manufacturing techniques and equipment . . . has more than 200 Power Packs in daily operation. The entire plant distribution system is a-c. Power Packs, ranging in size from 1 to 15 hp, convert a-c to d-c for adjustable-speed, field-control motors. Photo shows Power Pack conveniently located for supplying d-c power to a grinder.
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Westinghouse
Selenium POWER PACKS

machine on rails; standard, interchangeable machine units employed; hydraulic feed for drilling, reaming and countersinking; leadscrew feed for tapping. The Cross Co., Detroit.

MILLING MACHINE. Double-spindle, precision; especially adapted for light-duty work permitting two parallel surfaces to be machined in single pass of table. Spindles driven by pancake type motors; belt and gear drives provide 15 speeds for each spindle within range of 55 to 2080 rpm. W. H. Nichols Co., Waltham 54, Mass.

DEEP-DRAWING PRESS. Double-action type; provides two principles of force application—mechanical and hydraulic. Instantaneous adjustment of pressure by valves and direct-reading gages at any pressure point on blank holder which is self-adjusting for any thickness of stock. Can be converted to single-action. Verson Allsteel Press Co., Chicago 19.

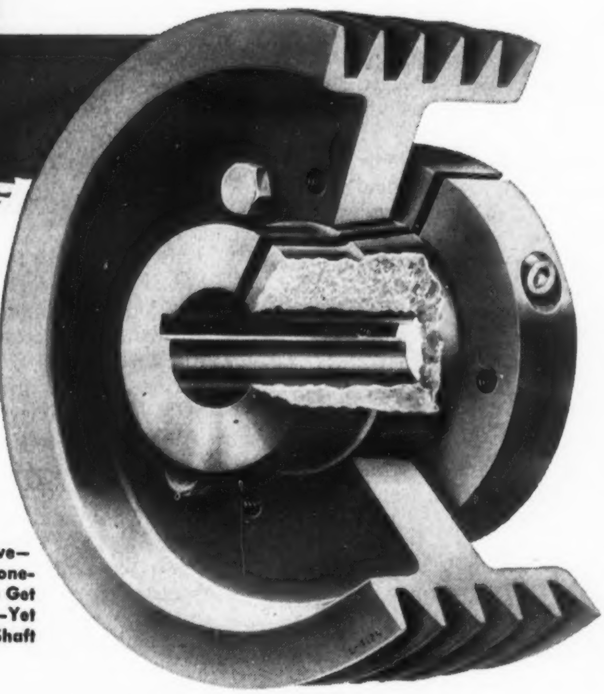
BROACHING MACHINE. Large, vertical, pull-up internal hydraulic type with height of 16 ft. 10 in. and weight of over 17 tons. Normal operating capacity, 30 tons; length of stroke, 60 in. The American Broach & Machine Co., Ann Arbor, Mich.

DRILLER AND REAMER. Automatic; nine-unit; for drilling and reaming refrigerator parts. Dial-feed type, using lever-operated pump jigs to hold part. Has electrical interlocking control. Simplex Tool Engineering Co., Detroit 1.

BACK-GEARED PUNCH PRESSES. Two types: 56-ton and 14-ton capacities. Former has shut-die height of 16 in., standard stroke of 3 in., max stroke of 8 in., bed area of 21 x 30 in., and operating speed of 50 strokes per min. 14-ton type has max speed of 65 strokes per min., standard stroke length of 2 in., and max stroke length of 4 in., bed area of 8 x 15 in., and shut-die height 7 in. for No. 14-A and 9 inches for the 14-B machine. Diamond Machine Tool Co., Los Angeles 23.

BORING MACHINE. Designed for solid cemented-carbide boring bars. Five-station, ten-spindle, with boring bar in each work-spindle. Spindle driven by 10-hp, 1800-rpm motor; table by 2-hp motor. Max outside diameter capacity of 6 in. and min. inside diameter of 1.4 in. Hoern & Dilts Inc., Saginaw, Mich.

BORING MACHINE. Two: Single and double-end types, for heavy work. Perform boring, turning, chamfering, grooving, facing or fly-cutting,



separately or in any desired combination. Up to 10 hp available at each spindle and higher for multiple heads. Hydraulically controlled. Heald Machine Co., Worcester 6, Mass.

STRAIGHTENING PRESS. 75-ton model for rough and finished work. Equipped with double-rail straightening fixture; ram has 12-in. stroke, a power stroke of 45 in. per min., and a return speed of 90 in. per min. Hydraulic system operated through 15-hp, 1800 rpm motor. Colonial Broach Co., Detroit.

INDEXING MACHINE. For drilling, counterboring, reaming and milling. Has automatic cam-feed unit driven by 5-hp motor, 15-spindle head. Can be furnished with three, four, eight and twelve-station tables, for automatic continuous cycle or intermittent operation with pushbutton control. W. K. Millholland Machinery Co., Indianapolis 5.

MULTI-OPERATION MACHINE. Drills, bores, reams, counterbores and taps automobile front-wheel spindle supports. Six-station machine, equipped with power indexing trunnion for transferring parts from loading station through five machining stations. Baker Brothers Inc., Toledo.

THREADING MACHINE. For portable pipe and bolts. Electrically driven; has standard capacity range for sizes from ¼ in. to 2 in. Variable-speed, reversible motor operates on either single-phase 110-volt ac, or dc. The Oster Mfg. Co., Cleveland 3.

SNAGGING GRINDER. Variable-speed machine, for use by two operators. Has two independent spindles and two 7½-hp motors, starters, pushbutton stations, etc. The Standard Electrical Tool Co., Cincinnati 4.

DOUBLE-END PUNCH. Distance between punching centers is 9 ft, with throat depth of 24 in. at each end. Beatty Machine & Mfg. Co., Hammond, Ind.

HYDRAULIC PRESS. Hand-operated, portable unit. Heating elements thermostatically controlled if electrically heated platens for plastics or other operations that require temperatures are desired. Studebaker Machine Co., Maywood, Ill.

Mining

MULTIFUEL ENGINE. 2-cycle, single-cylinder horizontal unit, rated at 34.3 hp at 450 rpm, with a 9½-in. bore and 10-in. stroke. May be operated as a cold-starting full diesel or converted to burn natural gas or butane, with conversion readily ac-

complished. White-Roth Machine Corp., Lorain, O.

TIMBERING MACHINE. Battery-powered, tire-mounted. Has hydraulically controlled boom. Boom can swing 90 degrees to either side of center. Baker Industrial Truck Div., Baker Raulang Co., Cleveland.

MAGNETIC SEPARATORS. Pulley type; self-contained. Designed for removal of tramp iron from chutes, hoppers, conveyor belts, etc. Standard models available with belts of any desired length in widths from 12 to 60 in. Dings Magnetic Separator Co., Milwaukee.

VIBRATORY GRIZZLY FEEDER. Heavy-duty, electric. Double magnet type, it is especially developed for large capacity operation of crusher feed; available in various styles, with variable control of feed, rate and either full or partial grizzly type. Operates on 220 or 440 volts ac. Syntron Co., Homer City, Pa.

Office

STENCIL MACHINE. For cutting stencils in oiled stencil board or plain cardboard for marking stencil addresses in shipments. Made in three character sizes: ½, ¾ and 1 in. Electrically operated with power supplied by standard 1/6-hp motor. Marsh Stencil Machine Co., Belleville, Ill.

Plastics

MOLDING PRESS. Automatic, one-piece-frame, heavy-duty press. Has slow-close automatic control system. High pressure at slowed-down press movement can be applied at any point in molding cycle, and is controlled by the positive action of a conveniently located cam. F. J. Stokes Machine Co.. Philadelphia.

Processing

DOUBLE-DRUM DRYER. For chemical or food processing. Welded steel used for end frames, knife assemblies, etc.; rounded corners, preventing accumulations. Conveyor troughs can be inverted. Drum drive speeds are variable by either mechanical or electronic controls. F. J. Stokes Machine Co., Philadelphia.

MIXER. For processing of rubber, plastics, and linoleum asphalt composition. One-piece mixing chamber is liquid and dust-tight; all gearing is totally enclosed and continuously lubricated in running oil bath; metal-to-metal shaft seals around blade axles at trough heads. Northmaster Mixer Dept., Struthers Wells Corp., Titusville, Pa.